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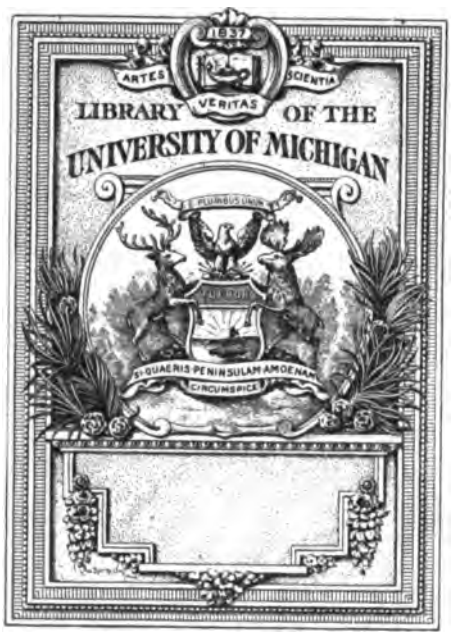
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GEOLOGY

OF

BELLARY DISTRICT.

MADRAS PRESIDENCY.

HEADINGS OF CHAPTERS.

Chapter I.—Introductory,
" II.—Previous Writers.
" III.—The Geological Formations occurring in Bellary District.
" IV.—The Archæan or Metamorphic (Gneissic) and Plutonic Rocks.
" V.—The Lower Transition, or Dharwar Rocks.
Chapter VI.—Intrusive Rocks in the Archæan Areas.
" VII.—High level lateritoid talus terraces.
" VIII.—Alluvial deposits.
" IX.—Subaerial formations and soils.
" X.—Economic Geology.
" XI.—Prehistoric Economic Geo-

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CORRIGENDA AND ADDENDA.

Page	2,	line	2 from	bottom read "East" instead of West.
"	6,	"	14 "	top insert "the" before Daroji Durg.
"	10,	"	12 "	bottom read "Eastern" instead of Western.
"	21,	"	19 "	top insert "hills" after Sandur.
"	26,	"	10 "	" " "were" before held.
"	31,	"	16 "	" read "9" instead of 8.
"	31,	"	10 "	bottom read "lies" instead of lie.
"	41,	"	3 "	top insert "South-West" after South.
"	62,	"	4 "	" read "Southern Mahratta" instead of Bellary Kistna.
"	64,	"	15 "	bottom read "Hagari" instead of Tungabhadra.
"	65,	"	12 "	top read "Emmiganur" instead of Emimganur.
"	65,	"	14 "	" " "Adhvani" instead of Advani.
"	71,	"	18 "	" omit the word "band".
"	77,	"	1 "	bottom insert whole line in front of "covered" in the first line of page 78.
"	100,	"	15 "	top read "Jonnala" for Jonnel.
"	114,	"	8 "	" insert "III" before (Plate V).
"	119,	"	9 "	bottom read "pseudo" for "speudo."

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MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

THE GEOLOGY OF THE BELLARY DISTRICT, MADRAS PRESIDENCY, *by* R. BRUCE FOOTE, F.G.S., F.M.U., *Superintendent, Geological Survey of India.*

CHAPTER I.

INTRODUCTORY.

THE district of Bellary, which forms the western division of the Ceded Districts (so called because ceded by the Nizam by treaty in 1800 tc the East India Company), lies in the centre of the Deccan table-land. Its most northerly extremity lies in Lat. N. 15° 58′ and its most southerly in N. Lat. 14° 30′. Its western extremity lies in E. Long. 75° 43′ and its eastern in E. Long. 77° 45′. The area of the district measures 5,904 square miles.[1] The western and northern boundaries of the district are formed by the Tungabhadra river, which divides it from Dharwar district and the Nizam's country. The southern boundary between the district and Mysore is exceedingly sinuous and nowhere dependent on great natural features of the country. The eastern boundary dividing Bellary from Anantapur is a purely

[1] Prior to the 5th January 1882 the district was much larger, as it included the taluqs now forming the Anantapur district, which has an area of 5,103 square miles. The areas quoted are taken from the Madras Manual of Administration.

fiscal one. The district is mapped in sheets 58 and 59 of the Indian Atlas, and its extreme western end occupies a small area in sheet 42.

General topography.—Excepting a very few square miles on the eastern frontier of the district, which are drained by affluents of the Penner, the whole area has a general slope to the northward and sheds the drainage into the Tungabhadra river.

The greater part of the inclined plane thus formed is open and but slightly undulating country, but the uniformity of the plain is broken by several ranges of hills which cross it diagonally at intervals in a north-west to south-east direction, beside which a number of small groups of hills, and several isolated hills, rise here and there between the several ranges. The district as a whole is remarkable for its bareness of trees, a sad fact due to the utterly reckless way in which the natives cut down trees without making provision for their being replaced. The evils caused by the want of forethought of the people are greatly intensified by the locust-like propensities of the large flocks of goats and herds of cattle they keep and by the practice of burning the dry grass on the hill-sides in the hot weather which kills all seedlings and saplings that may have chanced to escape the goats.

Orography.—Of the several hill ranges which, as before mentioned, cross the district diagonally in north-west to south-east direction, the most important is formed by the well-known Sandur hills which, rising close to the right bank of the Tungabhadra, stretch south-east for 32 miles, with only one break, the gorge of the Nari Nalla. This range is practically the centre of the district, which it divides into two unequal lobes, of which the north-eastern one is the larger by fully one-third.

The Sandur hills.

To the west-south-west of the Sandur hills, at a distance of about 32 miles, rises a high ridge, rather similar in appearance, and forms the Mallapan gudda range, which also starts from close to the right bank of the Tungabhadra at the western end of the Honur reach of the river and stretches south-west for 25 miles to the valley of the Chinna Haggari river. Here a gap, some seven miles in length, occurs, and beyond it the hills rise

Mallapan gudda hills.

again immediately south of the Mysore frontier and extend right across the State in a nearly unbroken line—the Dambal-Chiknayakanhalli band of the Dharwar system.

Kalhalli gudda hills.

Eight to ten miles south-west of the Mallapan gudda is another group of hills, which, in the absence of any local collective name, may as well be designated after their highest and most conspicuous member, the Kalhalligudda.

These hills run nearly south-east by south for nine miles, but then trend south-west by south, but their former direction is continued in a lower line of hills, some four miles off, which runs down close to the Mysore frontier. This latter line of hills may be called the Teligi hills after their principal member.

Sugammadevi Betta, or Copper Mountain ridge.

To return to the centre of the district—the Sandur hills. About six miles eastward of them lies another range, possessed of no collective native name, but which may well be called after its principal summit the Copper Mountain of the Europeans and Sugammadevi Betta[1] of the Canarese natives. The ridge is some 26 miles long from the south end of the great Daroji tank to the extreme south-east end, which lies only four miles west of the Haggari river. It is cut across by several deep saddles but there is no stratigraphical break.

The eastern half of the district is diversified by two lines of small groups and detached hills having a general north-west to south-east course, approximately parallel to the more western ranges.

Alur line of hills.

The western of these two lines of hills may conveniently be called the Alur line, as the most extensive and important cluster of them lies just north-west of the village of Alur, the Kasba of the taluq of that name. The line of hills starts from the right bank of the Tungabhadra at Kenchengod;[2] forms a striking cluster of hills around Hala Kota, which cluster extends south-east nearly to the Haggari river. On the right

[1] Or Sugalamma konda of the Telugu people.

[2] The line of hills crosses the Tungabhadra westward and forms the very picturesque group culminating in the Salgundi peak and terminates westward in the bold and precipitous Rawal konda (Rawducoonda of Sheet 58).

(east) bank of the latter river the line of hills recommences in the Kanchagar-Bellagal ridge, called Bellagal or White Rock, because of the great precipitous white quartz run which crests it for fully four miles. Other hills east of Hollalgundi connect it with the Alur cluster above referred to. South and south-east of Alur the line is continued by the Hatti Bellagal, Ram Durg, Naggaradoni, and Belldoni hills and ends in the Chippagiri hills, four miles north-west of Guntakal railway junction. The Alur line of hills lies about 30 miles north-east of the Copper Mountain ridge.

Adoni and Kotakal line of hills.

The second of the lines of detached hills above noted, which may suitably be called the Adoni and Kotakal line, might by some be regarded as a double line, but the several hills forming the two lines are not sufficiently far apart to treat them as belonging to two bends. The strike of this line of hills is rather to the south-east by south than to the south-east. This line of hills may be regarded as commencing about six miles south of the Tungabhadra, near Kosgi station on the North West line, Madras Railway, and extending to the east of Aspari (Aspree) station, some three or four miles into the Patti Konda Taluq, Karnul district. This line includes three main clusters, the Kamani Konda cluster, the Adoni cluster, 11 miles to the south, and the Kota Kal cluster 8 miles east-north-east of the latter. The length of the line of hills is 36 miles, and the plain separating it from the nearest hill in the Alur line is about 12 miles in width.

Gudikoté hills: Kudligi hills.

Two other groups of hills in which the arrangement is still distinctly linear, though less obviously so than in the Alur and Adoni-Kotakal groups, occur to the southward and westward of the Sandur hills: these are the Gudikoté hills and the Kudligi hills. The former lie south of the Sandur hills and stretch south-south-east down to the valley of the Chinna Haggari or Janaga nalla (river). Geographically they are continuous south-easterly with the Rayadrug cluster of hills (see p. 6), but politically they are separated by a projecting limb of Mysore territory, some eight to ten miles in width, which extends northward for a distance of rather

over 30 miles to a point some three miles north of the extreme south end of the Sandur hills. The length of the Gudikoté group of hills, from the base of the Sandur hills to the valley of the Janagahalla, is close upon 14 miles, and the width averages some 6 miles. The hills are high and immensely rugged, and the tract they occupy a very wild one.

The Kudligi hills.

The linear group of hills, to which I apply the collective name of Kudligi hills from the chief town of the Kudligi Taluq, which they surround on the north, east and south, extends from near Woblapur, seven miles south of Narayandevar kerra, in Hospet taluq, to a point 13 miles south-east of Kudligi. In length this line of hill measures 26 miles, with a maximum width of 8 miles at the southern end. They are lower and less rugged than the Gudikoté hills, but like them give rise to much wildly picturesque scenery. They culminate in Jerramalla Drug hill, which attains an elevation of 2,743 feet above the sea.

Detached clusters and isolated hills.

The detached clusters and important isolated hills must now be enumerated, and it will be best to take them from west to east.

Harapanahalli hills.

The first is a group of heights lying north and south of Harapanahalli town and lying between the Mallapan Betta and Kalhalligudda ridges. The highest points of this group are the Jitnakatti and Narasimdever Konda peaks, both of which are trigonometrical stations of the Survey of India. Narasimdever Konda has an elevation of 2,554 feet, and Jitnakatti peak looks to be rather higher. South of the last-named group, and separated from it by a valley, three or four miles in width, lies another group that may best be called the Uchingi Drug cluster after the famous old drug or hill-fort crowning the highest peak in the cluster. Excepting the Drug itself, they are lower and less rugged than those of Gudikoté, Kudligi, and Harapanahalli groups. The height of Uchingi Drug is 2,674 feet above sea-level. Proceeding north-eastward from the Harapanahalli taluq and across the Sandur hills, it is necessary to note two wildly

Uchingi Drug hills.

rugged and picturesque clusters which lie parallel to each other between the Sandur hills and the Tungabhadra. To these I will give the collective names of the Hampi and the Daróji hills from the two best known places adjoining them. They lie parallel to each other and are separated by a well-defined east to west valley, extending from a little east of Kamalapur to a little north of Daroji. Hampi, the remaining suburb of the old Hindu capital Vijayanagar, lies at the west end of the northern cluster, and Daróji at the east end of the southern one. Both are remarkably rugged, and in many parts highly picturesque. Some few years ago, when Mr. Kelsall wrote the District Manual, they appear to have been fairly well wooded, but are now very bare, except in a few inaccessible gullies. Timmapa Konda in the Hampi group, attains an elevation of 2,128′, and Daróji Drug hill is probably considerably higher.

Hampi and Daróji hills.

To the eastward of these, in the Bellary taluq, are sundry clusters of hills rising in the open plain far away from any of the ranges. These are, taking them from north to south, the Sirrigara hills, twenty miles north of Bellary, the Sindigiri hills, five miles south-east of the former, the Kurgode cluster, four miles south-west of the Sindigiris, the Bellary hills, the Sungankal and Kapgal cluster, four miles north-east of Bellary, and, lastly, the cluster west-south-west of Hirahal and about eleven miles south-west of Bellary town.

Excepting the Sindigiri group, which consists of hæmatite quartzites and schists, all these hills consist of granite gneiss of different sorts.

Twenty miles south of the Hirahal cluster lies Raya Drug, the centre of a large and important cluster of granitoid hills, which here attain to considerably greater height than any of the other granitoid clusters. Raya Drug hill is 2,799′, according to the Trigonometrical Survey, and the really grand mass of Kailasa Konda, 3½ miles to the west by south, measures 3,011′, according to the Mysore Topographical surveyors. With their greater height they also show greater beauty of form and

Raya Drug hills.

are more mountainous in appearance. A good many of the minor hills of this cluster are omitted from the Atlas Sheet (No. 59), though of sufficient size to have deserved representation.

The only remaining clusters of detached hills of sufficient size to deserve individual notice are the Halvi (Hallwy)[1] and Vurakonda (Oorkoonky) hills, in the north-western, and the Yemmiganur hills, in the eastern part of the Adoni taluq. Like the foregoing, they consist of granitoid rocks.

As before pointed out, the surface of Bellary District has a generally northerly slope down to the valley of the Tungabhadra. Along the southern boundary of the district, in the Harapanahalli and Kudligi taluqs, the officers of the Topographical Survey of Mysore made many closely adjoining hypso-metrical observations, which show the slope of the country very well. In the south of the Harapanahalli taluq the boundary approximates pretty closely to the 2,000′ contour line, but sinks to 1,730′ in the valley of the Tungabhadra and to 1,900′ in that of the Chikka Haggari. To the east of the latter river the level of the country rises again, so that to the south of the village of Ujinni (Oojinny) its elevation on the Mysore boundary line is 2,108′ and south of Nambalgiri 2,216′. From here the level of the boundary line falls very gradually south-eastward to the valley of the Janagahalla (or Chinna Haggari), where the elevation of the river bed is 1,971′ above sea-level. From this point the boundary keeps north-eastward along the left bank of the river, which falls to 1,766′ twenty-seven miles further down, at a place a little more than a mile outside the boundary, which there leaves the river valley and trends northward. The Janagahalla valley cuts across the promontory of Mysore territory, which here juts out far to the north, and shortly after the river re-enters the Bellary district near Kudlur, in Raya Drug taluq, it has fallen to the level of 1,534[1].

Elevation of the southern boundary.

From this point the boundary trends southward and rises to much

The names enclosed in brackets are those used in the Atlas sheets, most of which are incorrectly spelt, according to the Hunterian canon of transliteration, which is here followed, as it gives the pronunciation of the names much more accurately.

over 2,000′ in the hilly tract west of Rya Drug. South of the hills the ground falls rapidly southward, and just below where the boundary cuts the Haggari river the latter has an elevation of 1,640′.

Principal heights.

The heights of the summits of the different ranges and most important detached hills are given below. The greater parts were determined by the Trigonometrical surveyors, but others are taken from the maps prepared by the Mysore Topographical surveyors, and others again from those of the Madras Survey. They are arranged according to the taluqs they occur in. The initials "T. S." mean Trigonometrical Survey Station; "M. S.," Madras Survey Station; and "M. T. S.," Mysore Topographical Survey.

1. *Harapanahalli Taluq* (*Sheet* 59)—
   - Telligi hill (T. S.), 2,412′.
   - Kalhalli Gudda, 2,800′ to 2,900′ (estimated).
   - Narasimhadever Gudda (T. S.), 2,544′.
   - Huchangi Drug (T. S.), 2,674′.
   - Chettanhalli Gudda (T. S.) 2,440′, (not shown in Sheet 59).
2. *Huvina Haddagalli Taluq*—
   - Bettada Mallapan Betta (T. S.), 3,177′.
3. *Kudligi Taluq*—
   - Ujinni hill (T. S.) 2,370′ (Karankal Gudda).
   - Nimbalgeri Gudda (T. S.), 2,650′.
   - Jerramalla Drug (M. S.), 2,743′.
   - Machalbanda (M. T. S.), 2,662′.
   - Peddaperla (M. T. S.), 2,836′.
   - Peak south of Sandur synclinal (M. T. S.), 2,483′.
4. *Sandur State*—
   - Peak, north-east of Appianhalli (M. T. S.), 3,101′ (not shown in Sheet 59).
   - Peak, south-east of Appianhalli (M. T. S.), 2,976′ (not shown in Sheet 59).
   - Raman Drug, or Ramanmalla (T. S.), 3,256′.
   - Jambanath Konda (T. S.), 2,980′.
   - Kumarawami's peak, 3,400′ (General Cullen).
5. *Hospet Taluq*—
   - Timmapur hill (T. S.), 2,133′.
6. *Bellary Taluq*—
   - Bellary Fort hill (T. S.), 2,018′ (Schlagintweit).
   - Kurgode hill (T. S.), 1,966′ (M. S.)
   - Sugadevibetta (T. S.), 3,285′ (M. S.)
   - Guddur hill (M. S.), 1,674′.
7. *Raya Drug Taluq*—
   - Raya Drug (T. S.), 2,799′ (M. S.).
   - Kailasa Gudda (M. T. S.), 3,011′.
   - Darmapuri hill (T. S.), 2,474′.

8. Alur Taluq—
Chippagiri (hill), 1,690′.
Rama Drug (M.S.Stn.), 2,029′.
Arrakerra hill (T.S.), 2,127′ (Golagatta Konda).
Siddapan Konda (T.S.), 2,151′.
9. Adoni Taluq—
Adoni Fort hill (T.S.), 2,000′.
Kamani Kanda (T.S.), 2,101′.

Hydrography.—The hydrography of Bellary district is remarkably simple, as the whole drainage flows into the Bay of Bengal, and excepting a very few square miles of Raya Drug taluq, which shed their surplus water into the Penner, the whole district lies within the basin of the Tungabhadra, which is the chief river of the district, and which forms its boundary on the west, north-west, and northern sides for a distance of 209 miles. Where it first enters the district, at a point 8 miles below the great Harihar railway bridge, it flows at an elevation of 1,730′ above sea-level, and 60 miles further down stream, where the Bellary-Dharwar high road crosses the Tungabhadra at the Sovénhali ferry, the elevation of the river was determined by the levellings of the Survey of India officers to be 1,617′ above mean sea-level. At the Wallabapur anicut (weir), 28 miles lower down, the level has fallen to 1,581′, at Kampli to 1,200′, while at the Madaveram ferry, 127 miles below Sovénhalli, the level is only 1,046′ above the sea. At the great anicut at Sunkesala, further 33 miles down the river, the height of the river-bed above mean sea-level has sunk down to 948′. Sunkesala lies some 13 miles below the boundary between Bellary and Karnul districts, and the fall between this latter spot and the annikat is far more rapid than that of the 20-mile reach of the river extending westward from the boundary to the Madaveram crossing. The extreme north-east corner of the district must therefore have an elevation of very close upon 1,000′ above sea-level.

The Tungabhadra river.

The fall of the Tungabhadra valley.

The river, as shown above, skirts the districts for 209 miles, in which it descends 730′, if the assumption be correct that it leaves the districts at an elevation of 1,000 feet above sea-level. This would give

its bed an average fall of just under 3′ 6″ per mile, but in reality the fall is very unequal, as it descends chiefly by steps at varying intervals with intermediate still reaches. Considerably more than half the fall takes place in the 28 miles between the Wallabapur anicut and Kampli, in which the drop is 381 feet, giving an average fall of nearly 14 feet per mile. Many strong rapids occur in this distance, one of the principal ones being at Mellapore, where the river cuts through the north-western extension of the Landur synclinal. Below Hampi and Anagundi the fall is much less rapid. Another notable set of rapids occurs just above Kenchengode, in the northern part of Bellary Taluq, where the river breaks through a rocky tract representing the extension of the Halakotá hills into the Lalgundi hills.

Rapids.

In the upper reaches of the river that have to be considered here, there are remarkably few islands, and only one of them, just below Angur in Haddagulli Taluq, is worth naming. It is partly cultivated, but otherwise overgrown with dense, high, thorn jungle, but not inhabited, probably because covered by every high flood. Only five other islands are worth mentioning—those of Cooravagudda, just above the great rapid at Mellapur, and another smaller nameless one in the middle of the rapid which continues right down to the South Mahratta Railway bridge at Huligi. Of the other three, one is above the Kenchengode rapid, the second divides the river into two main channels in the rapid, and the third, the most important of all, commences just below the rapid and extends for over six miles down the river. On it stands the large village of Desanur and one or more hamlets, and great part of it is richly cultivated. The wooded islands abound in feathered game, especially peafowl. The deep pool-like reaches abound in fish, but few fisher people catch them, owing, I was told, to the numerous Singaites living along the river, who discourage fishing on religious grounds on and about Desanur Island. Otters are said to be very abundant, but the fishermen, who might be supposed to disapprove of their rivalry in fish-catching, are friendly to them, as they believe them to be very useful in destroying large numbers of young crocodiles who would otherwise grow

Islands.

into much more destructive fish-eaters. This is very likely true, and may possibly be one reason why I saw many fewer crocodiles in the Tungabhadra than in the upper part of the Kistna and its other tributaries.

In the gorge of the Tungabhadra at Hampi I came upon a pair of fresh-water turtle of very large size. They were probably examples of Kachuga (*Emys ilincata*).

The course of nearly all the tributary streams (a very few unimportant ones at the extreme western end of the district excepted) is northward. Of these various tributaries only two really deserve the name of rivers: these are the Haggari (or Vedavatti) and the Chikka (or Little) Haggari, the former of which flows through the centre of the district, while the latter, nearly 60 miles further west, bisects the western half of the same. Both rise in the Mysore territory.

The Haggari river.

The Haggari, despite its great size and moderate fall (which, according to General Fisher, R.E., averages six feet per mile), is in its character very torrential; it is nearly dry for a great part of the year, but after heavy rains comes down in violent floods, which do much harm to the wet cultivation on its banks. Such was the case in 1851, when, in consequence of a great rain-storm, it rose so high as to destroy the town of Guliam (Gooleum) on its right bank and to do great damage to sundry other villages and cause great loss of human life. During the dry months the westerly winds carry much sand out of the broad bed of the river, which generally dries up entirely, and pile it on the right bank into dunes of some size, much to the detriment of the villages adjoining. More than one village has been overwhelmed by the easterly advance of these blown sands. Jiraganur, two miles north of the Haggari station, South Mahratta Railway, is an example of the destroying energy of the moving sands.

Blown sands on the right bank.

Where the South Mahratta Railway croses the Haggari, a little north of Peruma devanhalli, the river flows at an elevation of about

1,330′ above sea-level.[1] Six miles further north the river-bed at the Moka ford has fallen nearly to 1,300′.

The principal tributary of the Haggari is the Janagahalla, or Chinna Haggari, which drains all the southern part of the western half of the district.

The Chikka Haggari river.

The Chikka Haggari in the western part of the district offers no special feature of note.

Of the minor streams tributary to the Tungabhadra, none is more than a nallah. The principal ones to be noted are Haggarnur nallah, rising at Harapanahalli and draining the broad valley west of the Mallapan Betta hills; the Hampasagara nallah; the Hampapatana, or Ballahunisi (Bullahoonshy) nallah, which drains the hilly country north of Kudligi, and the Gauripur nallah, which runs along the western base of the Raman Drug range.

Minor streams tributary to the Tungabhadra.

The Nari halla, which flows through the Sandur valley by the Oblagandi and Bhimagandi gorges, is a more important stream than any of the above three. After being dammed up to form the great Daróji Tank, it flows into the Tungabhadra by a nearly due northerly course. For its size it is a most useful stream, as it furnishes water for a great deal of irrigation along its banks. The two gorges by which it enters and leaves the Sandur State are very remarkable geological features.

The Nari halla.

Eastward of the Haggari valley several large nallahs find their way down to the Tungabhadra, but none offer any points of special interest. They mostly flow through wide monotonous plains covered with cotton soil, and very few of them are utilized by the people for irrigation purposes, though many of them could be dammed back for the formation of tanks, if the people had a greater spice of energy in them. Only two need be named separately, the Harivanam nallah or Kariji Vanka, which is of great size and drains

[1] 1,342·33′ *minus* the height of the bridge above the river-bed.

the northern half of the Alur and the western half of the Adoni taluqs. The Chinna Tambalam nallah deserves notice, because it drains the hilly tract north of Adoni and is lower down dammed back to form the great Chinna Tambalam tank.

Fiscal and Political Divisions of the District.—The district is divided at present into eight taluqs, the central ones of which surround the small State of Sandur. The latter consists of a long valley, enclosed between two considerable hill ranges, and is inhabited by Canarese people ruled over by a Mahratta Rajah of the historic house of Ghorpadé. The hills are thickly covered with low jungle and high coarse grass, and, except where the ground is precipitous or much broken, few sections are seen unless after a great jungle fire. In a few damp ravines and sholas remains of thick forest are to be seen and occasional old stumps of large trees are scattered about, showing that the soils resulting from the decomposition of the old traps and schists were as rich as might be excepted from their origin and at one time bore trees of respectable size and good value. As the greater part of the Sandur forest tract has been leased by Government and great efforts are being made to prevent forest fires, there is good reason to anticipate that in due time the hills will become once more well wooded, a condition of things tending greatly to benefit the surrounding country by cheapening timber and firewood and causing many springs and streams which are now intermittent to become perennial again. These measures may have a very beneficial tendency in reviving the charcoal iron industry of the country which still languishes round the base of the hills.

Sandur State.

The Bellary taluq is mainly a great plain covered for the most part by thick spreads of cotton soil, out of which rise at intervals large and small isolated rocky hills of granite gneiss, which have been pretty well denuded of the jungle that formerly covered them. It is only in the south of the taluq that any really important hills exist, to wit, the Sugadevi Betta or Copper Mountain ridge, and its north-western and south-eastern

Bellary Taluq.

extensions. These too have been utterly denuded of their normal covering of forest. The most striking feature of the whole taluq, and indeed of the whole district, is its extreme treelessness. Excepting in topes and gardens around towns and villages trees are but rarely visible, and this is most markedly the case over the great black cotton soil tracts.

As a rule, without any important exceptions, the foot of every important hill is surrounded by a belt of red soil of variable width, but in general proportionate to the size of the hill. In some apparent exceptions to this rule a close examination of the neighbourhood will show that this has been effected by wet cultivation, whether in former time or by cultivation still in progress.

Alur Taluq.

The description of Bellary taluq applies very closely to the Alur taluq, the latter consisting of a wide plain divided in the centre by a group of hills, the main axis of which runs north-west to south-east. The watershed between the Haggari and the Hindri (a small river flowing into the Tungabhadra at Karnul town) is formed by the high regur-covered tract on the eastern side of the taluq. A few square miles only drain eastward into the Hindri, but the southern and western sides are drained into the Haggari and the northern side into the Tungabhadra through the Kariji Vanka. Alur taluq is as treeless, as a rule, as Bellary taluq, if not more so, thanks to the folly of the people. The greater part of the taluq is occupied by cotton soil.

Adoni Taluq.

Adoni or Adwani taluq, which includes the old Nagaldinni taluq, as well as the Adoni taluq proper, has a very hilly centre, but is flat on the west, north, and north-east sides. The centre and south-east part of the taluq is almost entirely covered with red soil in its sandy or loamy varieties. The western and northern sides of the taluq consist on the contrary of cotton soil (regur) in typical treeless plains of great extent.

Raya Drug Taluq.

To turn southward again, Raya Drug taluq is mainly flat; the northern half of the taluq is entirely so, only two or three unimportant hillocks standing out

to diversify the nearly dead-level cotton soil flat. The southern half contains the Raya Drug mass, the Kailasa and the Dharmapuri peaks, and numerous other less important hills, and around and among them are considerable red soil spreads.

The tract of Mysore territory running up north between the Raya Drug and Kudligi taluqs is very hilly, except in its north-eastern part, which is just an extension of the great cotton soil plain of the Haggari valley forming the northern half of the Raya Drug taluq.

Kudligi taluq.

Kudligi taluq is very hilly in its eastern and central part, and is mainly occupied by sandy pale red soils. Cotton soil spreads are not very common nor very extensive. They lie chiefly in the western part of the taluq, near the valley of the Chikka Haggari. The hills in the north-eastern part of the taluq have not been entirely denuded of their forest covering, and energetic measures are being taken to retrieve the mischief done by decades of neglect. Except where covered with thick lateritic crusts, the hills are capable of supporting forest of good quality. The valleys between the granitic hills are generally characterised by the presence of fine trees, if any at all are allowed to grow. Tamarind trees and banyans, of great size and beauty, are frequently seen, and very frequently also stumps and roots of similar old trees of yet greater size still remain,[1] showing that they were formerly much more plentiful than now. Very many of the streams flow between strong thickets of wild date which help greatly to make the stream perennial. The date trees flourish exceedingly when not tapped for toddy and in unfrequented parts of the country spread readily, and have, where they grow thick, a most beneficial tendency in stopping the injurious action of flood waters. They grow luxuriantly on poor sandy soil, so long as they get sufficient moisture to start them. The exceeding luxuriance of their growth in this part

[1] About a mile east of Kudligi town stands one of the large and finest specimens of the true banyan (*ficus indica*) I have ever seen. It is an incomparably finer, loftier, and larger tree than the famous specimen in the Howrah Botanical Gardens, and in size and thickness of top second only to the noble tree at Melur, in Madura district, the finest of its kind as far as I know.

and in the adjoining Harapanahalli taluq, and generally on the Mysore plateau, seems to indicate the desirability of trying to grow the Arabian date in this part of the Deccan, as if it succeeds it would be of incalculable benefit to these poor and often famine-troubled highlands. The Arabian date would take the place of the wild one and be grown sedulously for the sake of the rich food-supply it yields. The fruit of the wild date, though edible and much sought after by children, is too small to form an important article of food and would doubtless in time be replaced by the Arabian, which is too valuable as a food-plant to be destructively tapped for its sap only. The eventual substitution of a tree yielding a rich supply of food, for one yielding only an injurious intoxicant, could hardly fail in the long run to confer a very genuine blessing on the people generally.

Harapanahalli Taluq.

The Harapanahalli taluq, which forms the south-west corner of the district, is mainly hilly and undulating in its surface, and the only approximately flat country lies along the left bank of the Chikka Haggari, where are the only spreads of cotton soil large enough to be worth noticing. The greater part of the taluq is covered by red soil and the valleys are, as a rule, fertile and capable of growing large and fine fruit and timber trees. The stream valleys would appear admirably adapted for the culture of the Arabian date palm, as was pointed out above. Very little forest remains on the majority of the hills, but the Forest Department is at work, and if duly encouraged will in a few years cause the reserved tracts to make a visible show.

Owing to the greater number of suitable valleys they contain, the western taluqs show a much larger number of irrigation tanks than do the much more level eastern taluqs.

Huvina Haddagalli Taluq.

Huvina Haddagalli taluq, the next in order, is the least hilly in the whole district, as, excepting the northern end of the Mallapan Betta range and the northern spur of the Kalhalli Gudda, there is not a single hill of any importance within the taluq. The general surface of the taluq is undulating and considerable spreads of cotton soil occur in the northern and east-

ern parts. The right bank of the Tungabhadra is fringed in many places with extensive beds of coarse river shingle lying at levels of from 30 to nearly 100 feet above the present level of the river and much above the levels attained now by even the highest floods. The shingle beds are usually of a pale cinnamon brown or pale raw sienna colour from the great quantity of quartz pebbles they contain.

Like the greater part of the district, Haddagalli taluq is remarkable for its bare and treeless aspect.

Hospet Taluq.

We come lastly to the Hospet taluq (formerly the Kampli (Kumply) taluq), the most central of all and the most hilly. It includes the western, north-eastern, and eastern flanks of the Sandur hills and the western flanks of the Sugadevi Betta (Copper Mountain) ridge, while its northern half is occupied by a great triple group of rugged granite gneiss hills lying north of the railway and the Gadiganur Valley. This group includes the Hampi (Vijayanagar) hills at its north-western and the Daróji hills at its south-eastern extremity. The whole group abounds in wild rocky picturesque scenery. The view from the top of Martanga Parvatam, a temple-crowned hill, occupying nearly the centre of the famous old Hindu capital, is one of great but strange beauty: across a perfect maze of wild rocky hills and huge tors to the west, north, and east, while to the south, across a rich undulating plain, rise, wall-like, the Sandur hills, culminating at this end in the bold peak of Jambu Nath konda (2,980 feet high). Just a little north of the Martanga hill lies a deep and narrow gorge through which the Tungabhadra now flows northward, while both to the west and east its clear waters flow in a variety of broad or narrow reaches and add greatly to the beauty of the scene. The contrast between the bareness of the block-covered hills and the luxuriant vegetation in the narrow valleys between them is a very striking feature.

Rainfall.

Climate and Meteorology.—Bellary district lies in the "Dry zone," of from 15 to 30 inches of annual rainfall, and in the hyetographic map, compiled by the Meteorological Department, is credited with a mean annual rainfall of 15

inches, which is the lowest shown in South India. In reality, however, it is rather less dry than the adjoining parts of Mysore, *e.g.*, the taluqs of Hiriyur and Dodderi, which receive in parts an annual supply of less than 10 inches.[1]

The monsoons.

The district is remarkable for its dryness, for, though it is subject to both the monsoons, it gets the full force of neither. The greater supply of rain is given by the south-west monsoon, which blows from the first week in June to the beginning of October, the direction of the wind being generally from the south-west or west. In October the north-east monsoon begins, and north-easterly (and more rarely easterly) winds prevail till March, when westerly winds set in, but bring no rain from the western sea, the so-called mango showers which occasionally appear in April and May being thunder-showers of local origin.

The cold season.

The cold weather begins with the cessation of the north-east monsoon rains in November and lasts till the end of February. The days are lovely, but the nights cold, the thermometer often falling below 55° towards morning. Fogs in the morning are not of common occurrence. They rarely interfered with my field-work. One which I experienced in January 1890 in Harapanahalli taluq was so rich in moisture that all my tents inside a thick mango tope were as perfectly soaked as if a heavy shower had fallen, and the ground around them well wetted, so great was the condensation effected by the trees. One tent which stood in the open was left dry. I never witnessed a more striking example of the condensing power of trees. Had the neighbouring hills been covered by good trees instead of bare, they would have enriched the country with a very welcome supply of moisture, for the condensing process went on for several hours.

Fogs.

The hot season.

The hot season in Bellary district lasts from the end of February to the breaking of the south monsoon—generally a little over three months. The heat

[1] See Rice's "Gazetteer of Mysore and Coorg," Vol. II, p. 454.

is great, but not so great as in the adjoining districts to the east, in which the hot, generally westerly, winds attain to a much higher temperature. Owing to the dryness of the atmosphere, the heat is to most people far less injurious than the lesser but damp heat of the coastal districts.

Hot winds.

In the western taluqs the winds hardly attain to a sufficiently high temperature to deserve to be called hot winds, but to the eastward of the Sandur hills their temperature rises rapidly and by the time they have reached Bellary town they are decidedly hot, but only moderately so as compared with the heat attained by the winds passing over Karnul, Northern Cuddapah, and Nellore districts. On the whole Bellary district rejoices in one of the best and healthiest climates in Southern India, and is for nine months in the year very enjoyable.

Temperature.

The range of temperature in Bellary district is great, as is the case all over the Deccan plateau, the nights being often very cold and the middle of the days very hot. The effect of this on the rocks is very marked in the extraordinary amount of fracture they have undergone in places where no other external forces could have affected them.

The range of temperature in Bellary town, from registered observations as given in the District Manual, appears to me much too small, doubtless because based on a very brief series of observations.

Prevalence of westerly winds.

The prevalence of westerly winds has already been pointed out. A noteworthy geological proof of this is the fact of the accumulations of blown sands raised from the generally dry, broad, sandy bed of the Haggari river, all lying on the right or eastern bank of the river. The trees on the summits and most wind-swept ridges of the different hill ranges and groups frequently show a strong tendency to lean to the eastward, though this feature is not nearly so marked in Bellary district as on the high plateaus of the Sahyadri Mountains, or Western Ghâts, in the Belgaum country and Southern Kolhapur.

I have no personal experience of Bellary district during the south-west monsoon, but that season has the reputation of being a very pleasant one, the days being cloudy and the air fresh.

Like many other districts lying within the "Dry zone," Bellary has suffered frequently and severely from famines. Many traces of such exist in the ruins of abandoned villages and hamlets, numbers of which are to be met with throughout the district.

Scenery.

A very common idea exists among people who know the district but imperfectly, that it is a generally very ugly one. This is far too sweeping a condemnation for any part of it, and for a great part of it the reverse of true.

The great black soil plains which are traversed by the railways are certainly not beautiful, even when green and crop-covered, because of the dull and sad colour of the soil and the extreme treelessness of the landscape, but they are redeemed in most parts from monotony by the numerous picturesque rocky hills which rise out of them as islands out of the sea. Even in the hottest part of the hot weather the scenery is diversified by these numerous hills, and it is only when they are shut out of sight by mirage and thick waving heat haze that the term "ugly" can be at all deservedly applied to the landscape, and that only during the middle of the day. No green grass remains and the only green to be seen is that of a few scattered nim trees and babuls.[1] The black soil is deeply cracked in every direction and becomes difficult and tiring to walk over, and very dangerous for fast riding.

In the mountainous and hilly parts of the country there is much picturesque scenery, and some of the gorges in the Sandur hills, and the gorge of the Tungabhadra at Hampi, are really beautiful.

[1] *Melia indica* (Margosa) and *Acacia arabica*.

CHAPTER II.

PREVIOUS WRITERS.

The earliest paper on the Geology of Bellary district that I am acquainted with is one published in the *Philosophical Magazine* for 1828, by Captain W. Cullen (afterwards General and for many years Resident in Travancore), under the title "Notice of the Geological Features of a Route from Madras to Bellary in April and May 1822." The paper really relates to tracts lying in the eastern parts of the Ceded Districts, far outside of the Bellary district in its widest definition, and to the rocks mostly belonging to the Upper Kadapas and Lower Karnuls of the Survey classification, which occupy the country north-east of Gooty and are now divided between the Karnul and Anantapore districts. His remarks, applicable to rocks lying within the present Bellary district, only occupy a couple of lines touching upon the granitoids east of the Haggari, and are of no importance.

Captain Cullen.

The next writer who treated of the Geology of the Bellary district was Captain T. J. Newbold, F.R.S., of the Madras Army, who made a number of traverses through various parts of the district, descriptions of which were published in the journals of the Asiatic Societies of London and Bengal and in that of the Madras Literary Society.

Captain Newbold.

The principal papers which concern us here are the following:—

1. Notes, principally geological, on the tract between Bellary and Bijapur—*Journal, Asiatic Society*, Bengal, XI, pp. 929—940. (1842).
2. Notes, principally geological, from Bijapur to Bellary *via* Kannaghirri—*Journal, Asiatic Society*, Bengal, XI, pp. 941—955. (1842).
3. Description of the valley of Sondur.—Madras, *Journal, Literary Society*, VIII, pp. 128—152. (1838).
4. Notice of River Dunes on the banks of the Hogri and Pennaur.—Madras, *Journal, Literary Society*, IX, p. 309. (1839).
5. Notes, principally geological, from the banks of the Tumbuddra to those of the Cauvery.—Madras, *Journal, Literary Society*, XI, pp. 126—143.
6. Summary of the Geology of Southern India.—*Journal, Royal Asiatic Society*, VIII.

Captain Newbold did far more to elucidate the Geology of Southern

India up to the establishment of the Geological Survey than all the other writers and investigators of the subject taken together, and his work deserves full notice, for most of it was well done according to the geological views prevalent in his day, and where it is found wanting it is mostly due to his necessarily incomplete knowledge of countries only traversed and therefore imperfectly examined.

His description of the topography of the "Sondur" (Soondoor, properly Sandur) State is very good, and so is his account of the rocks as far as it goes.

The principal point on which his views cannot now be accepted is his assumption that the schistose bands in the peninsula have been brought into their present positions by being broken through by great outbursts of granite. At first sight this appears to be the case, but on closer and more extended examination of the country this idea is found to be untenable, for the old granitoids are nowhere seen to be irrupted into the schists; on the contrary the latter were deposited on the former by quiet, long-continued sedimentary action. This is of course a total change of the relative positions of the two rock series: the granitoids assume their true position as the true fundamental rocks of the country, and the schists are seen to be vastly younger in age than Newbold supposed them to be.

The granitic intrusions in the schist series which Newbold regarded as intrusions of the granitoid mass are all found to be intrusions of much younger pegmatoid veins, and of very small extent and importance.

The schists are not in the modern sense of the term "hypogene schists;" they are truly and unmistakably sedimentary formations associated with contemporary trapflows, and whatever metamorphism they have undergone since their deposition is due to great movements of the earth's crust, which led to their being bent up into great folds forming huge synclinals and anticlinals. When this had happened a period of vast erosive action ensued, and thousands of feet in thickness of the schistose series were removed and the underlying granitoid foundation was again exposed; while much of the eroded

material was re-deposited as the rocks of the younger Kadapa and Karnul systems.

The equivalents of Newbold's "hypogene schists" in the Bellary district belong to the system I have called the Dharwar system.

The great extent to which the contemporaneous trapflows in the Dharwar system in the Sandur are covered up by the hæmatite talus appears to have led him to underestimate the importance of the trap-elements in the local system.

He frequently alludes to the existence of actinolite in localities where I could only find pistacite, a pale variety of epidote. As a matter of fact, I never came across a single crystal of actinolite in any part of Bellary and the districts adjoining it, though I found it in various places in Salem district and elsewhere in the south. Pistacite, on the contrary, is exceedingly common in many of the granitoids.

Schlagintweit.

In 1855-56 a traverse of the Magnetic Survey of India by the brothers Schlagintweit was made across the centre of Bellary district by one of the brothers (Adolf?), but the geological notes he recorded I have not had access to.

Geological Survey of India.

In the end of 1869 a geological traverse was made by me through the Adoni taluq, along the line of the Madras Railway and extending for a distance of about 4 miles on either side. The information then gained was not published separately, being of no special interest. The object of the traverse was to connect the Azoic rocks of the Kadapa and Karnul basins with the supposedly equivalent rocks in the upper valley of the Kistna and that of the Bhima. This was done, and the Kaladgi and Bhima series shown to correspond to the Kadapa and Karnul series,

District Manual.

The Manual of the Bellary district, compiled by Mr. John Kelsall, M.C.S., and published in 1872, contains a sketch of the geological features, drawn chiefly from Captain Newbold's notes, and entirely so for the taluqs which now form the district, for they, with the exception of my small traverse through Adoni taluq, had not been examined by any other geologist.

The sketch given in the Manual was as good as the geological material then existing and compiled by a layman would admit it to be, but the topography of the district was very imperfect and the volume further handicapped by the disgracefully rude map that was allowed to accompany it.

Several references to what was then known of the geology of the district were made in my Memoir on the geological features of the South Mahratta country and adjoining districts, (Memoirs) Geological Survey of India, XII, pt. 1, 1876.

The Author.

At the end of 1884, the regular geological survey of Bellary district (in its present form) was taken up by me, and it was completed in March 1890, but with several long interruptions to the systematic work. In the season of 1887-88 I had the assistance of Mr. Philip Lake, B.A., Cantab., but unfortunately only for a few weeks in Bellary district. Though quite a young geologist, Mr. Lake had been highly trained and proved himself a good and careful observer, and I would very gladly have had his help to the end. A few notes of interest made by him will be found further on.

In 1886 appeared in the Records (Geological Survey of India, XIX, 1886) some "Notes on the Geology of Parts of Bellary and Anantapore," in which I gave a preliminary sketch of the distribution of the Dharwar rocks in the Bellary district in three bands, as was then supposed, and pointed out that nearly all the principal goldfields then known in the peninsula lay in basins of that age.

The name of "Dharwar" had been first applied by me to the schistose series in my notes on a traverse across the goldfields of Mysore which appeared in 1882, in the Records (Geological Survey of India, XV, p. 191). The knowledge I gained of the different bands of the schist which traverse Mysore had quite determined me that it was necessary to treat them as a distinct system, not to be mixed up with the older gneissic and granitoid series any longer, and the name "Dharwar" was very suitable, as that important town stands on the largest of the schist bands; the band, in fact, in which I

first recognized the unequivocally sedimentary character of the rocks composing it.

In 1888 appeared the first part, and in 1889 the second part, of a paper on the "Dharwar System, the chief auriferous rock series of South India" (Records, Geological Survey of India, Vol. XXI, p. 2, 1888, and *ibid*, Vol. XXII, pt. 1, 1889), which embodied all the further knowledge gained about the system in various parts of the peninsula, but specially in Mysore and the Raichur Doab (in both of which I had made tours intermediately), and the adjoining parts of Bellary. The fresh light thus thrown on Bellary district was the proving of the existence of a narrow band of Dharwars branching up north-westward into the Harapanahalli taluq from the great Dambal-Chiknayakanhalli band, near Chitaldroog, and the working out the division of the Penner-Haggari band northward of Bellary and up the valley of the Tungabhadra to Kampli. In the way of negative information it was shown that there was no extension southward of the Tungabhadra of the great Maski Dharwar band in the Raichur Doab, and lastly, but not leastly, the structure of the Sandur and Copper Mountain synclinals, both of them tough geological problems and the most interesting pieces of the Dharwar system in British territory, had been made much more intelligible.

No publication dealing with the Geology of Bellary district has since appeared in India as far as I know, but in a paper in the "Annuaire Géologique Universel" (Jour. VI, p. 575) M. Emm. de Margerie, in reviewing the work of the Geological Survey of India in the Deccan, calls special attention to the strong lithological resemblances between the members of the Dharwar system and those of the typical Huronian group in the Lake Superior country, and so the very remote antiquity of both systems.

CHAPTER III.

THE GEOLOGICAL FORMATIONS OCCURRING IN BELLARY DISTRICT.

The rock formations met with in the District may be conveniently arranged in four principal groups as in the schedule here given:

	IV. Recent and Post Tertiary.	*Subaërial:* Talus formations.—Cemented Taluses.—Pseudo-Lateritic Breccias.—Kankar formations.—Blown sands.—Regur.—Red soils.—Mixed and white soils. *Alluvial:* Modern alluvial deposits (loams and shingle beds) of the Tungabhadra and its tributaries.—Fossiliferous Travertin.—Consolidated shingles.—High level gravels (old alluvium) of the Tungabhadra.—Shingle fans.
	III. Tertiary (?)	*Terrace Laterite.*
Azoic.	II. Lower Transition.	*Dharwar system*—Principal metalliferous rocks in South India.
Azoic.	I. Archæan or Metamorphic and Plutonic.	Granitoids and gneisses with associated traps, etc.

CHAPTER IV.

THE ARCHÆAN, OR METAMORPHIC (GNEISSIC) AND PLUTONIC ROCKS.

The Archæan rocks, which form the fundamental series in the peninsula, are very largely developed in the Bellary district and occupy fully five-sixths of its area. Their extent alone therefore renders them the most important geological series to be treated of, and they are deserving of much interest and of far closer study than could be bestowed upon them because of their general poverty in minerals of economic importance, to the quest for which much more time had to be devoted.

Taking the district as a whole, it must be described as consisting mainly of granitoid rocks, generally of porphyritic character, the metamorphic or gneissic crystallines playing a very subordinate part in most places, though of such great importance in other parts of the Madras Presidency.

Division of the Archæan rocks.

The rocks met with over the Archæan area show considerable variety in their composition and structure (texture), as might be expected, and they may be divided accordingly in the first place into granitoid and gneissic, and again, in the second place, according to their mineral composition, into the following groups :—

A. PLUTONIC GRANITOID.

a. Orthoclase, quartz, hornblende.—Granitoid, and mostly strongly-porphyritic (Hornblendic granite).—Colour, dark grey or purplish pink, weathering reddish or brownish.

b. Quartz, orthoclase, hornblende.—(Quartz Syenite), rarely porphyritic; colour, silvery grey to dark grey; weathering grey or whitish; mica occasionally as an accessory mineral.

c. Orthoclase, quartz, hornblende, or mica, rarely visible; probably younger than "*a*" and "*b*;" often very pegmatoid in appearance. Colour, pale grey? : weathering pale, dirty pink.[1]

B. METAMORPHIC GNEISSOID.

d. Quartz, orthoclase.—Hornblende : gneissic in texture or semi-granitoid and banded.

e. Quartz, orthoclase.—Mica : gneissic in texture or semi-granitoid and banded.

Both members of the gneissic division appear younger than "*a*" and "*b*" of the granitoids; their relations to "*c*" have not been ascertained, and they have not been noted in juxtaposition *inter se*. The inter-relations of "*a*" and "*b*" have yet to be established, no section having been met with which showed them in contact.

Why not mapped separately.

No attempt is made to show the different varieties of granites and gneisses in the map; they are too much mixed up in nature to admit of being mapped separately, except after a much more exhaustive survey on much larger scaled maps than I had the means or the time for making.

Past and present views concerning the crystalline rocks.

The view which was some years ago so very prevalent among geologists that granitoid rocks, where met with in great mass, must be regarded as of originally sedimentary origin and converted into their present crystalline conditions by vast metamorphic action, appears to me, after long study in the field (largely in the Bellary region), to be quite untenable. The rocks which I had learnt to regard as derivative

[1] This granitoid is always deeply weathered and, being of no value as a building material, is hardly ever broken into deeply enough to show its proper colour.

metamorphic granite gneisses must, it appears to me now, be considered true Plutonic rocks—Granites and Syenites. This is in measure a reversion to older petrological views, such as held by Newbold and other geologists of his day. But the reversion is only a partial one, for Newbold looked upon the mass of the granites of the peninsula as by no means the oldest rocks to be met with, but on the contrary as much younger than not only the true gneisses but also than the yet far younger Dharwar rocks, which he called the hypogene schists and describes as upheaved and broken through by the granite. There can be no doubt that such irruptive action of granite never took place on a large scale, and that the vast areas of granitoid rock now seen were really the old foundation on which the gneisses, and after them the Dharwar rocks, were quietly deposited. After the deposition of the Dharwars a period of great disturbance supervened, and they were crumpled into great folds with a generally north-west to south-east strike. The underlying granitoids necessarily participated in this great deformation, and to it much of their quasi-bedded structure must be attributed. The period of deformation was succeeded by a period of great, and probably subaërial, denudation, with the result that the granitoid foundation was again exposed over great areas.

Newbold's granite irruptive, not plutonic.

The study of the crystalline rocks in Bellary district has shown that they are as a rule very unlike the mass of the gneisses in the east and south of the peninsula, but *per contra* that they bear a very strong likeness petrographically to the Bandelkhand gneiss of Central India, which was described by Messrs. Henry Medlicott and W. T. Blanford, in the Manual of the Geology of India, as the oldest known rock series in India. The resemblance is not only a petrographical one in hand specimens, but also a very striking one in the features of the landscapes of parts of these two widely remote regions—a likeness abundantly confirmed by comparison of good photographic views of the granitoids in both tracts.

Bellary crystallines unlike to eastern gneisses, but like Bandelkhand crystallines.

"The long narrow serrated edges of quartz reefs" which form such

frequent and striking a feature in the Bandelkhand landscape are nearly as common in Bellary district and other parts of the Ceded districts, and they not unfrequently attain to heights of 500 to 600 feet and upwards above the general level, like those in Central India. The granitoids in Bellary district and the adjacent districts of Anantapur, Karnul, and Kadapa are also traversed by very numerous trap-dykes of great size and length, which often rise into bold crests and ridges forming very conspicuous objects in the landscape. The relation of these to the granitoids and to the great quartz reefs is precisely the same as in the typical Bandelkhand area.

A further noteworthy fact, in perfect agreement with the geolcgical structure of the Bandelkhand gneiss, is the total absence, as far as our present knowledge goes, of limestones in the granito-gneissic region of Bellary, the South-Mahratta country, the Raichur Doab, and the districts of Anantapur, Karnul, and Kadapah. Yet another point, in which the granitoid gneisses of Bandelkhand and Bellary show a strong similarity, is in the extraordinary rarity of accessory minerals—a point in which they differ much from the gneisses in the Eastern Carnatic.

There cannot to my mind be any doubt that the granitoid rocks within the region above defined should be regarded as belonging to the Bandelkhand or older division of the great Archæan system of India, despite that they are divided from each by hundreds of miles of overlying strata of younger formations (chiefly the flows of the great Deccan trap system).

The recognition of the existence of this older division of the gneissics in the tracts just named necessitates the mention of its occurring also in other parts of the south of the peninsula, to wit, in great parts of Mysore, in the central and western taluqs of North Arcot, and in the Baramahal division of Salem district.

Inliers of identical character appear also in the centre of the Kistna and the south-west of the Nellore districts, in the south-east of North Arcot, and the centre of South Arcot; also in the south of Trichinopoly district, the Puddukotta State, and part of Madura north of the

Vaigé river. A yet more southerly inlier occurs in south-western Tinnevelly.

The Salem gneiss.

The gneisses of the Nilgiri plateau bear a greater resemblance to those forming the Salem mountains (including the Patcha Malais, Koli Malais, Shevaroys, Tainanda Malais, and Kalroyen Malais, which extend north-north-eastward into the Javádi hills) and constitute an apparently younger (upper) division, to which the name of the Salem division may not unsuitably be applied for the present at least, until it may possibly be correlated with the Bengal division, after the intervening large Archæan area in Vizagapatam, Ganjam, and Orissa shall have been geologically surveyed.

The Southern Ghâts, which include the Travancore hills, the Anamalais, and the Palani (Pulney) mountains, together with the schistose gneisses of Coimbatore district, will most probably be shown to belong to the Salem gneiss.

To this upper division may very appropriately be assigned the very peculiar schistose gneisses of the Kistna and Godavery districts (described as the Bezwada gneiss by Dr. King and myself, when writing on the geology of the Eastern Coast), unless, indeed, it should eventually be shown that a third division ought to be established to include these very remarkable gneisses.

The relation of the Bellary granitoid and the Salem gneiss series is very obscure, and the boundary lines between them have yet to be worked out.

No special classification of the crystalline rocks lying within Bellary district was found practicable, the chief obstacle being the very great extent of the spaces between well-marked bands in hilly tracts, where the surface is wholly or mainly concealed by the wide and unbroken spreads of regur, and in some parts, though to a lesser degree, by those of sandy red soils, and by shingle spreads in others. The information to be obtained from isolated small out-crops, or shallow exposures in small stream beds, is rarely to be trusted, as in the vast majority of cases the rock is in a state of advanced decomposition.

Question of the origin of the Archæan rocks.

An examination of the Archæan rocks of the Bellary and adjacent districts, in which exceedingly granitoid forms predominate so largely, at once raises the question of their origin—whether they are old Plutonic rocks in which pressure and contortion have induced in some parts a pseudo-bedded structure, or whether they are simply very ancient sedimentary formations, which have been locally extra-affected by regional metamorphism continued for longer periods and to a greater extent than in the case of their equivalents in other parts. The phenomena displayed by the rocks themselves appear at some places to favour the first, and at others the second, hypothesis, and it is extremely difficult, in fact practically impossible, to decide by mere macroscopic study of the rocks which hypothes is to favour. The immensely granitoid structure prevailing, almost exclusively, over such large areas favours the first hypothesis, while the remarkable parallelism subsisting between the strike of the bedding and the strike of the great bands of different mineral constitution which traverse the country, such as the Bellary, the Kapgal, the Alur, the Adoni,and the Yemmiganur bands to the east of the Sandur synclinal, and the Chornur, Kudligi, and Harapanahall, bands to the west of it (*vide* pp. 2 to 7), certainly favour the second hypothesis. It remains to be seen whether the problem will be solved when the microscopic investigation of a large number of specimens from the different rock bands shall have been completed. Till then at least the subject will remain *sub judice*. My personal conviction tends more and more to the hypothesis that the Bellary granitoids and their representatives are really old Plutonic rocks arranged in bands—flows, in fact, of old acidic magmas modified by the immense lateral pressure they underwent during the crumpling period, after the formation of the Dharwar rocks system.

The most notable fact concerning the general distribution of the crystallines is the general persistence of the strike of the bedding, which is mostly from south-east to north-west, and shows but few variations from that direction, and none of them extending over any great areas. Hardly any of these are of sufficient importance to be referred to separately.

For convenience of description, the crystalline area may be treated of in seven quasi-natural subdivisions, which will be obvious from mere cursory inspection of the map and which will be considered in succession from west to east. They are the following:—

Crystalline area described in seven subdivisions.

1. *The Harapanahalli-Uchingi Drug Subdivision*, which lies between the Dharwar-Shimoga band and the Mallapan gudda (Dambal-Chiknayakanhalli) band of the Dharwar rocks.
2. *The Kudligi-Raya Drug Subdivision*, lying between the Mallapan gudda (Dambal-Chiknayakanhalli band) and Sandur bands of Dharwars, and extending south-eastward from the Tungabhadra to the Mysore frontier.
3. *The Hirahal Subdivision*—a very small area lying between the southern part of the Sandur band and the Copper Mountain range, and bounded on the south by Mysore territory and the great cotton soil plain of the Haggari Valley.
4. *The Hospet Subdivision*, which lies between the northern part of the Sandur band of Dharwars and the northern part of the Copper Mountain range and the Kampli patch of the Dharwars, and is bounded on the north-west by the Tungabhadra river.
5. *The Bellary Subdivision*, between the Copper Mountain band and the Haggari river.
6. *The Alur Subdivision*, between the Haggari river and the western base of the Adoni line of granite hills.
7. *The Adoni Subdivision*, which includes the north-eastern extremity of the district from the Adoni hills (inclusive) to the Tungabhadra, 30 miles to the north-east.

(1.) *The Harapanahalli-Uchingi Subdivision.*—The northern part of this band, which is its narrowest part, is an open rolling plain, chiefly covered with cotton soil and showing very few outcrops of rock, except in the bed and bank of the Tungabhadra, which are rocky. As the band widens southward into the Harapanahalli Valley it becomes more broken in character, and numerous hills, from one hundred to three or four hundred feet high, arise, due to the superior hardness

of intrusive runs of brecciated quartz and to large trap-dykes. Indeed, the neighbourhood of Harapanahalli presents one of the most remarkable series of brecciated quartz runs to be seen anywhere in the peninsula.

Narasimha-dever gudda.

To the southward of Harapanahalli rises a considerable plexus of low but often very rugged granitoid hills, at the southern extremity of which (eight miles south-south-east of Harapanahalli) Narasimha-dever gudda, a very bold and picturesque hill, rises some 500 feet above the surrounding plain and 2,544 feet above sea-level. Narasimha-dever gudda consists of grey, banded, granite gneiss, the bedding of which is unusually distinct when seen from the south-east, and dips at an angle of about 50° to the south-south-west, and appears to underlie a great thickness of coarse, greenish or greyish green potstone, which lie a little distance to the south-west, and further south, still forms the bare, blocky, rounded mass known as Arsapur hill. Whether these beds of potstone belong to the gneissic series, or whether they should be reckoned as part of the younger Dharwar system, which also contains beds of potstone, is doubtful, and is a point that can only be determined hereafter by yet closer examination of the country.

Uchingi Drug.

Seven miles south of Narasimha-dever gudda rises the higher, but much less picturesque, mass, of Uchingi[1] Drug, a very bare, steep, rocky ridge, about a mile in

[1] *Uchingi Drug* (written variously Oochingy, Huchangi, or Vutsangi), a famous old durgam or hill-fort, of immense strength in olden times, was one of the seats of the important Poligar family of Harapanahalli. The family belonged to the Boyas, or Beders, a low-caste, but very bold and sport-loving tribe, from which arose many of the leading Poligar families in the Deccan; among them the Poligars of Wakingeri and Surapur (so lovingly and graphically described by Meadows Taylor in "The Noble Queen" and "The Story of My Life"), also those of Raya Drug and Chital Drug.

A story is still told by the Uchingi Drug people that one of the Harapanahalli Poligars, Thattiah Naik, who acquired the drug as part of his wife, Honnai Magathi's dower from her father, the Naik, or Poligar, of Chitaldrug, fell out with the latter some years after his marriage. Finding that his wife sided with her father, Thattiah Naik took her one day to one of the bastions overhanging the town, on the pretence of showing her her father's country, and then suddenly pushed her over and thus murdered her. The cliff over which she fell into the tank below is still called after her Honnaigeré, and the tank Honnai Honda. I am indebted for this story to T. Mootoogopal Pillay (Hospital Assistant, Madras Party, Geological Survey of India), who took a very intelligent interest in

length from north to south, which forms the eastern end and highest point of a considerable group of wild, rocky hills which extends southward close up to the Mysore frontier. Uchingi Drug hill consists of a very massive granitoid, showing little or no lamination, but its eastern face presents the appearance of a great plane of bedding which dips eastward under a narrow band of Dharwar rocks running up northward from the Mysore boundary, and forming the northern extension of the Halékal gudda branch of the great Dambal-Chiknayakanhalli band of the Dharwar rocks. A band of potstone appears to rest directly on the great sloping plane above referred to, but neither its contact with the granitoid, nor its contact with Dharwar schists and quartzites to the eastward can be seen, and so it remains doubtful to which system it belongs.

Potstone bed at Uchingi.

Of similarly doubtful age are the other potstone formations which occur at intervals further to the north-west and north-north-west. I could not get any sections showing their contact with the surrounding crystalline rocks, nor were any of them seen in contact with unmistakably Dharwar rocks. Such little evidence as was obtained as to their relationship to other rocks appears to favour the hypothesis that they belong to the Archæan system, rather than that they are outliers of the basement of the Dharwar system that were saved from erosion by having been folded in with the Archæan rocks rather deeply at the time of the great crumpling of the Dharwar system. The principal occurrences of the potstone to be noted, besides the Uchingi bed already referred to, are—

Other outcrops of potstone: Arsapur, Nilgunda, etc.

a. The Arsapur hill, five miles north-north-west of Uchingi Drug;

b. The Nilgunda hill band; and

c. A group of three outcrops lying west of the great tank at Harapanahalli town.

matters of local history and folklore, subjects to which the natives of South India, and the Canarese people more especially, are, as a rule, supremely, indifferent. There seems to be an extraordinary dearth of legends connected with the geological features of this Bellary country. I could hear of none other despite constant enquiries.

Three small outcrops occur at distances of about two miles each, two to the east and one to the north by east of Kanch Kerra, five and seven miles north-west by north of Uchingi Drug, respectively. Yet another small outcrop occurs about half a mile south of Angur (Ungoor), on the Tungabhadra, 19 miles north-west of Harapanahalli.

Of the several outcrops, only *a*, *b*, *c*, and the little outcrop at Angur, seem to have been worked for building stone, for pot-making material, or for small ornaments. At Arsapur, at the northern end of the outcrop, just west of Narasimha-dever gudda, a considerable industry in potstone vessels is now in swing. At Nilgunda, a beautiful little temple has been built on the bund of the great tank, of fine grey potstone said to have been quarried there.

The great mass of the rock, both at Arsapur hill and Nilgunda hill, is very coarse, with granular fracture, and varying in colour from dirty olive-green through bluish green almost to black. Only the light greenish grey fine-grained parts of the rock are worked, and an account of the potstone industry will be found in the Chapter on Economic Geology (Chapter XI).

Excepting Uchingi Drug and Narasimha-dever gudda, the granitoid rocks form no hills of any size or demanding any special notice.

The low hill lying south-west of Harapanahalli consists of a fairly well-bedded, pale grey granite, which has been largely quarried. It shows the north-westerly strike which prevails in that quarter. It has a very low dip of from 20° to 30° only, an unusual thing in the granitoid rocks.

Wildernesses.

A great wilderness of granitoid rocks in low hills lies between Harapanahalli and Arsakerra and a similar but smaller one occurs to the west of Uchingi Drug, but neither present features of sufficient interest to merit further notice.

Narasimha-dever gudda.

Narasimha-dever gudda and the ridge to the east-south-east consist of a fine "stripey" granite gneiss, with a well-marked dip of 50° to 60° south-south-west, which is particularly well seen from a few miles to the south-east. The

quartz occurring in the rock is of unusually limpid character, which allows the black mica to show through in many places and produces a very rich grey colour. It is largely quarried.

Banday type of granite gneiss.

A variety of granite gneiss not often met with occurs four miles to the northward of Harapanahalli in shape of a very finely laminated rock, in which the laminæ of white felspar and black mica, at very frequent intervals, make a wavy curl round a small nucleus (of quartz?), which produces a speckled appearance of a very pleasing grey colour. It is specially well seen at Banday, close to the new high road, where it forms low "whale back" hills; it is considerably developed there and to the north-westward, with a strike parallel to the axis of the Mallapan Gudda Dharwar band. It would appear to be an unusually small-eyed variety of "Augen gneiss."

(2.) *The Kudligi-Raya Drug Subdivision.*—This section of the granitoid area is a very large one, occupying as it does the whole of Kudligi taluq and the greater part of the Huvin-Haddagalli and Raya Drug taluqs, besides a corner of Hospet taluq. In plan it forms a broad band, about 70 miles long on its longer or eastern side, and 30 wide, stretching from the right bank of the Tungabhadra to the boundaries of Mysore and the Anantapur district.

The examination of the greater part of this great tract had unfortunately to be but a cursory one. I was instructed to get over it as speedily as possible, only making sure that no outliers of the more metalliferous Dharwars were overlooked. To do this a sufficiently close net-work of traverses was made, to obtain a general idea of the distribution of the principal granitoids and gneisses occupying the subdivision.

Gneissic rocks of the western part.

The whole of the western side of the band is occupied by gneissic rocks, with a few small exceptions in the way of bosses of granitoid rocks, to be named separately further on, and which appear to be inliers of the older granitoids exposed by denudation and not intrusive masses. In the northern part of the area, the course of the Chikka Haggari is pretty

closely the boundary between the gneissic band and the granitoids to the eastward of it. The whole of this gneissic tract is very flat, with hardly a single prominence to break the monotony of the plain, and it is only along its western side that a few striking hills—the granitoid bosses just referred to—rise from the flat.

Granitoids of eastern part.

The eastern and larger half of the area (subdivision) is occupied by granitoid rocks belonging chiefly to the groups "*a*" and "*c*" above defined. The relations of these two groups and their distribution need much further study before they can be understood and represented graphically.

The granitoid half of the area, instead of being flat and monotonous, is in most parts dotted over with numerous hills, and in many places extremely rugged and hilly the hills, rising from 500 to 1,000 feet or more above the plains and affording much wildly beautiful scenery. The topographical features of this area have already been described in the introductory chapter (*ante* p. 6) and need not be repeated here.

Groups of hills met with.

The hill groups met with may conveniently be called the Kudligi and Gudikoté (Goodicotta) hills, the latter continuing south-eastward, across the north extremity of Mysore, into the Raya Drug group, which geographically include the fine mass of hills around Molakal Muru (Molakal Mooroo) in Mysore.

Gneissic tract very flat.

It has already been noted that the gneissic rocks forming the western half of the band have been weathered down to a very level surface, and the plain they form is thickly covered by cotton soil. Not a single good section was met with and none showing them in juxtaposition with the granitoid rocks. They are seen at intervals in the banks of nullas, but are everywhere immensely weathered and tremendously cut up by innumerable veins of a whitish pegmatite of all possible sizes. The two best sections of them I met with were in the off-flow channel of the great tank at Kotturu (Cottoor) and in the banks of the nulla at Itugi (Hittigay), a tributary from the west of the Chikka Haggari, but in both of these it was impossible to find any part of the rock

that was not in an advanced state of decomposition. In its weathered condition the gneiss is a quartzo-felspathic, whitish, flakey mass. Here and there are somewhat hornblendic bands in the gneiss, which show a much less advanced stage of weathering. The gneiss rolls about freely.

Granitic hills west of the gneiss tract.

To the westward of the gneiss rise the granitoid hills of Utingi (Hootengy) and Tullakal, and to the south the Kankappa gudda near Nandi Bevur (Nundy Bayoor), which is a felspathic, micaceous, granite gneiss, in which the lamination of the rock, as seen in a small quarry on its western side, is rippled in a very beautiful manner.

Rocks in the north-western corner.

To the north of Utingi hill the Hollagundi hill, of grey hornblendic, granite gneiss, forms the most conspicuous object for many miles around. The beds forming it sweep round in a semi-circle to the north-west and form Timappan gudda, another conspicuous hill three miles off. The northerly extension of the Timappan gudda beds forms a low jungle-covered ridge, which stretches away nearly up to the Tungabhadra.

Tremolite gneiss.

This gneissic band does not extend quite as far west as the bank of the Tungabhadra. Granitoid rocks begin to take their place about a mile east of the river. A little distance east of the boundary near the Coarlagutta tank occurs a bed of an uncommon form of gneiss, in which the ordinary black hornblende is replaced by the white variety or tremolite; the only occurrence of this mineral in South India that I am personally acquainted with. With the tremolitic bands are intercalated bands of ordinary hornblendic gneiss. The outcrop of the tremolite gneiss is of very limited extent as far as seen.

Between Hollagundi and Moragerry, six miles to the east, several outcrops of gneiss are crossed by the path—extensions apparently of the gneiss seen in the Itugi (Hittigay) nulla. To the north-east of Moragerry the cotton soil gives place to reddish sands, full of the *débris* of pegmatite veins. Outcrops of the granite gneiss underlying are few and far between.

Granular quartz rock.

To return for a little while to the tract east of Kankappa gudda, near Nandi Bevur. Half-way between Kankappa gudda (hill) and Kalhalli (Cullhully) is a low reddish ridge, which at a little distance looks very much like a run of brecciated quartz rock, but on close inspection proves to be a bed of granular quartz rock, identical in appearance and texture with the quartz rocks which figure so largely in Madura district.[1] Associated with it, intercalated with it in fact, are quite thin beds of greenish gneiss, in which the mica spangles are intensely green, but the quartz only moderately coloured, apparently from the presence of copper.

Further south, along the western side of the subdivision, outcrops of rocks are exceedingly few and far between. Those lying near the Dharwar band, in the bay it there forms, are granites, but further east the gneissic band is met, but has greatly narrowed from its more northerly width.

Gneisses near Ujinni.

At Ujinni (Oojinny) and to the west-south-west and south of it are a few outcrops of typical hornblendic gneiss. At Ujinni, immediately south of the village, the gneiss is seen in a well section to dip due south at an angle of from 40° to 50°.

The hornblendic gneiss extends across the boundary into Mysore, and there is an interesting section of it to the east of Sokke (Sooka) for 200 to 300 yards along the bed of the small stream draining the tank there. The gneiss is most extraordinarily cut up by veins of red pegmatite, large and small and often anastomosing.

Garnets.

Much hornblendic schist is to be seen in the Kaikol gudda, a considerable ridge rising on the boundary line to the south of Nimbalpur. The ridge is indeed mainly composed of the hornblendic schist, in which occur veinlets of quartz containing iron-lime garnets. Garnets are very rare in the Bellary rocks, the only other place where I met with them being near the green gneiss outcrop in the south spur of the Mincheri hills.

[1] See Memoir on the Geology of Madura and Tinnevelly, Vol. XX, part 1.

Much of the country near the Tungabhadra is obscured by cotton soil, but hornblendic gneiss and schist may be seen in slightly rolling, sometimes almost horizontal, beds cropping out here and there, *e. g.*, three miles west by south and south-west of Hampasagra. At that place itself there is a considerable show of micaceous schistose gneiss in the rain-cut gullies south-east of the village. The country to the south-westward of Hampasagra forms regular rolling downs with long gentle swells.

Gneisses near the Tungabhadra.

To the east of Hampasagra the gneiss assumes a semi-granitoid character, but is strongly banded. Micaceous gneiss prevails, but hornblendic gneiss is also to be seen along the course of a small stream which rises south of the high road and runs down to the Tungabhadra, past Sheganhalli (seven miles east-north-east of Hampasagra). With the hornblendic gneiss is intercalated a bed of magnetic iron, small and unimportant in size, but interesting because of its rarity in this region.

Further east, along the Dharwar-Bellary high road, are many large masses of the semi-granitoid gneiss, which here dips to the north-east. The rock is a well-banded black and white granite gneiss, much crumpled on a small scale and cut up by many good-sized veins of dense grey-white granulite and small veins of pegmatite. It is particularly well seen on Bandarangan gudda, a low temple-crowned hill 1½ miles north-east of Tambrahalli (Tumberhully).

To the south-east of Tambrahalli the granitoid region begins as pointed out above; but no exposures of any interest or size occur till several miles to the south. The tract traversed by the high road up to the Gauripur (Gourypoor) pass, over the north end of the Sandur hills, is occupied by a highly felspathic granitoid belonging to group "*c*" of the schedule above given.

Felspathic granitoid tract.

This highly felspathic rock occupies a considerable tract to the south-east of Narayandeverkerra and extends southward to beyond Dannayakenkerra, where it seems to merge into the granitoid of group "*a*;" but this cannot be asserted positively, as this part of the country was only cursorily examined.

A great show of granitoid rock occurs on each side of the valley of the Hampapatna nullah, in the hills rising west of the valley from the northern end of the Kudligi line of hills (see p. 5). The extreme north end of the line is formed by the elliptical, steep-sided, whale-back hill occurring at Pinjar Heggadahall, two miles west-south-west of Hampapatna. It consists of a highly felspatho-micaceous, granite gneiss with the banding much contorted.

The Kudligi line of hills.

The general character of the granitoid seems to be continuous throughout the Kudligi line of hills; they present similar bold features, and many of them boast of fine conspicuous tors. The scenery they make is very pleasing. By no means all the hills are shown in sheet 59, some of considerable size having been omitted.

The rock forming the high downs between Hanashi and Timlapur, 5½ miles west of Kudligi, is a felspatho-quartzose, granite gneiss with both mica and hornblende in combination. It is traversed by many, and sometimes large, veins of pegmatite. The dip of the rock is north-eastward, and at the low angle of 20°.

Rocks around Kudligi.

The banded granitoid forming Shiddan gudda, the conspicuous temple-crowned hill south-west of Kudligi town, is much contorted, and also much cut up by large and small veins of pegmatite.

To the east of Kudligi, at a distance of five miles, the road crosses a thin band of magnetic iron, whose north-eastern continuation joins the magnetic iron bed which cuts across the Kudligi-Sandur road four miles north-east of Kudligi. The bed is rather poor in magnetite, which is included, as it were, in the quartzo-hornblendic laminæ of the rock. It is an inlier of gneissic character in the granitoid area.

Magnetic iron bed.

Four miles south of Kudligi rises the boldly picturesque Viran durga (Veeran Doorga), consisting of highly porphyritic, micaceous granite, with inclusions of hornblendic rock. The rock is coarsely banded in parts. The old durga is quite impregnable from any side but the north, where the

Viran Drug.

village snuggles into the front of the hill. It is well worth climbing and of extra interest, because the scene of a defeat of Tippoo Sultan, who tried to take the drug by *coup de main*, but failed and drew off his troops in disgust at the bold defence made.

To the south-east of Viran Drug the Kudligi line of hills divides into two lines, of which the eastern is much the higher and bolder, and includes the famous old stronghold of Jerramalla, one of the strongest and most important drugs in the country in pre-British times. Jerramalla Drug crowns a very fine hill which rises to a height of 2,742 feet above sea-level, and some 800 feet or so above the surrounding plain. The rock is a typical non-porphyritic granite of moderately coarse texture. It is far more shut in by other hills on all sides but the east than the map (sheet 59) would lead one to suppose, and is a most inaccessible place from the south at least. The panorama from the summit is very extensive, and it commands the best and most instructive view of the southern slopes of the Sandur hills that I am acquainted with. The line of the Kudligi hills comes to an end four miles south-east by south of Jerramalla Drug.

Jerramalla Drug.

The tract lying between Jerramalla, Ujinni, and the Mysore boundary is, in its northern part, eminently granitic, the Byradaver Drug and Haurkabauvy gudda being the principal hills of that rock. Further south and south-east the granite forms no striking eminences, and near the boundary to the south-east of the conspicuous quartz-crested Nimbalgiri gudda black hornblendic gneiss with pink felspar laminæ makes some show and extends for two or three miles east, and is then replaced by hornblendic granite, well-banded, which extends to Hosshalli. From Hosshalli this hornblendic band extends up north by west towards the Haurkabauvy massif. It is greatly cut up by pegmatite.

Tract south of Jerramalla.

To the east of Hosshalli, associated with ordinary granite, is a long narrow belt of a kind of quartzite which has a greenish tint imparted to it in parts from the presence of numerous grains of epidote; in other parts it is cream-coloured.

Lokakaira quartzite.

Its northern end forms the Cuttahullybode Trigonometrical station hill, a low but sharply cut ridge. To the south of this it sinks down somewhat and becomes less conspicuous. At Lokakaira it rises again into a ridge about a hundred feet in height. The bedding is obscure and dip doubtful. No contact with the granite was seen by which to judge of their exact relations. From the Lokakaira hill, the band continues to the south-south-west to beyond Boopsundrum and away across the boundary into Mysore hidden under the red soil spread. The band is six miles long and about a quarter of a mile wide.

An equally obscurely bedded but non-epidotic quartzite forms the Yerra Pujari hill, two miles to the eastward. This appears to be continuous (unless faulted in échelon), with two other irregular quartzite hills to the south-east. On the southern extremity stands a little hamlet, called Tippahalli, close to the left bank of the Janagahalli river. The rock is lost sight of in the alluvial strip on the river's bank.

What the age of these quartzites may be can only be speculated on. No evidence to help towards a solution of the problem could be found.

Potstone.

On the maidan, between the Lokakaira hill and the Yerra Pujari hill, I noticed many fragments of good grey potstone lying about, but could see no source whence they could be derived. They were not relics of a local industry, and it is quite possible a bed from which they were derived may be hidden under the local alluvium.

Magnetic iron.

On the south side of the granite hill lying north-west of Immady Samudra, two miles west of Hurlihal (Hoorlyhall), is a small development of magnetic iron, not of sufficient importance to be economically important in a place so near to the vast hæmatite stores of the Sandur hills.

Shiddagal iron-smelting works.

Six-and-half miles north by 5° east of Hurlihal, in a granite tract abounding in fine tors, stands Shiddagal, a fine pale grey rock crowned by a small fort. Shiddagal is the site of an active iron-smelting industry. The ore worked

up is rich, earthy hæmatite, brought on bullocks' backs from the Adar gani (mine), about 1½ miles west of the famous Kumaraswami temple on the south plateau of the Sandur hills, and described on page 121.

To the eastward of Shiddagal, between it and Gudikoté, stands a long line (six or seven miles) of considerable granite hills, high enough to shut out Gudikoté hill itself from sight. The map, sheet 59, takes no cognizance of their existence.

Hornblendic and micaceous gneisses.

Many bands of hornblendic gneiss are crossed in the scrubby jungle lying between Hurlihal and Shiddagal: they lie about half way between the two places.

Dark micaceous gneiss occurs also to the south-south-east of Hurlihal, and to the eastward many beds of hornblendic gneiss, while beyond them a very granitic region extends down to the Janagahalla (river), which is the Mysore boundary.

Gudikoté line of hills.

The Gudikoté (Goodicotta) hills form a line only, if the Raya Drug hills be considered as their extension, which they should be, geologically and geographically, though fiscally and politically the line is cut across by a broad strip of Mysore territory which runs up north for some 15 miles beyond the point of intersection.

Bandari hill dome.

The northernmost hill that I would reckon as belonging to the Gudikoté line is a great domoid mass,[1] lying close south-west of the village of Bandari (Bundaree) on the Kudligi-Sandur high road. The granitoid forming it is a close-grained compact rock, very similar in appearance to that forming the great dome of Máchál Banda, 11 miles to the south-east. The rock here is pale grey, very felspathic granite gneiss with a northerly dip.

To the south-east of Bandari hill and between the villages of Govanhall and Hirahal, on the banks of the Narihalla, is a perfect labyrinth of grey granite, in low rugged hillocks and hummocks, spread

[1] Bandari hill, though a large and important one, is omitted from sheet 59, as are many others in that part. Máchál Banda is a Trigonometrical station and attains to 2,662 feet above sea-level.

over many hundreds of acres. So rugged is this tract that having through the stupidity of my guide (a local man), got entangled in it with my horse, I had very serious difficulty in getting the animal through safely.

At and around Chornur the granite gneiss is a well-banded grey and black variety, with a vertical dip, and striking a degree or two west of north.

The hills all around Máchál Banda are blocky instead of smooth, which generally indicates a rock of coarse grain, if not positively porphyritic in texture.

Gudikoté Giant Scree.

As Gudikoté is approached the grey granite changes to a bluish tint, and the size of the blocks into which it weathers, increases immensely, those in the Gudikoté hill itself being about the largest I have seen in any part of South India. Here, too, the blocks are lying about in the wildest confusion, and make access to the summit of the hill a labour of great difficulty, although the direct distance cannot be more than 2 or 300 yards. I tried to gain the summit with the help of a guide who professed to know the way, but after an hour's very severe climbing failed to accomplish my purpose, and had to give it up because it was getting dark. Many of the blocks are 20 and 30 feet long and nearly as thick. The climb could not be accomplished without a ladder. When the fort was in use there must have been passages known to the garrison, and in some places passages had been deliberately blocked up.

The rocks east and north-east of Gudikoté are very porphyritic and often show systems of vertical and horizontal jointing, which give rise to the formation of mural lines of scarping which might easily deceive people unacquainted with the peculiarities of structure of these hills into the belief that the hills had in part been artificially shaped.

Peddaperla hill.

The culminating point in the Gudikoté hills is Peddaperla Trigonometrical station, a noble hill rising to the height of 2,836 feet above sea-level, and with one

exception, the highest of the granitoid hills in the district. The summit of Peddaperla is, thanks to its mural scarps, very castellated in appearance, and offers a strong contrast to the smooth outline of the adjoining non-blocky granite gneiss hill east of Uppayanhalli, which consists of a highly felspathic rock like that of the Máchál gudda Trigonometrical station.

Inclined plane at Golla Linganhalli.

In the northern part of the group the western side of the valley of Golla Linganhalli, close to the south end of the Sandur synclinal, is formed by a smooth inclined plane of granite, like that forming the eastern side of the Uchingi Drug ridge and described above, p. 32—apparently a great plane of bedding, perfectly clear and visible from a moderate distance, but not by any means obvious, nor measurable as to its angle, when close at hand.

Granite country west of Raya Drug.

The four to eight miles of Mysore territory which intervene between the main mass of the Gudikoté hills and the Raya Drug, are occupied by a tract of country of singular beauty. The bold rocky hills which rise out of it in every direction are divided from each other by equally picturesque valleys full of fine trees, amongst which tamarind trees, pre-eminent for their love of granitic soil, abound. The road from the Travellers' bungalow at Hanagal (on the Bangalore-Bellary high road), which skirts the south side of the line of hills for the first five miles, and for the next four passes right through them, takes one through scenery not easily forgotten for its striking beauty in grand rocks and rich vegetation. Molakalmuru and Kailasa, the former in Mysore, the latter in British territory, are the two highest and the most striking of the granite peaks in the whole of this region, the former measuring 3,022 feet, and the latter 3,011 feet, above sea-level. Raya Drug itself is a fine mass; but from its proximity to the town to which it gives its name has been almost completely stripped of vegetation, which gives it a bare and damaged appearance. It consists of a grey granite, weathering into large and rather more than usually rounded blocks. The old fortifications are very extensive; and, from their

extent and commanding positions make it easy to understand what a mighty stronghold it was in former times.

Kailasa, which lies about three miles south-west by west, a far finer looking hill, splendidly scarped and naturally castellated, beside being 200 feet higher, was left unfortified, because, according to a native account, there was insufficient accommodation for water storage.

Granite hills east of Raya Drug.

To the east of Raya Drug, the only granite hill of any size and importance is the mass culminating in the Darmapuri (Durmapoory) Trigonometrical station (2,474'). A large spur of this mass, which crosses the new high road from Raya Drug to Kanakal (Cunnacull) and Malyam (Maulayau), consists of strongly-banded hornblendic granite gneiss, the bedding striking N. 5° W. with a high easterly dip. It is very soon lost sight of under the great black soil spread which covers the plain drained by the Haggari and Jannagaballa rivers, a spread of black soil covering over 500 square miles of country, with only six or seven visible inliers of the old rocks.

Bellaguppa hills.

The Bellaguppa hills, 10 miles east of Darmapuri peak, are small rocky hills consisting of a slightly hornblendic granite of fine grain and speckly in appearance. In colour it is purplish red or grey, with dark grey bands and some black hornblendic inclusions. The rock shows but little lamination, but there is a distinct bedding on a large scale which is very conspicuous in the north-western part of the hills. Except for the fact that Bellaguppa hills stand across the boundary, they ought really to be reckoned part of the Kallian Drug group of hills, which are seen standing up in bold and graceful shapes some eight or nine miles to the south. These, as seen by sunset light, reminded me, despite the great difference in size, very strongly of the Sinaitic mountain group seen from the Red Sea. Both colour and shape bore a strong resemblance.

Another noteworthy hill belonging to this group, and only four miles south-west of Bellaguppa hill, consists of a lofty, almost conical, domoid mass standing on the back of a broad low dome. It is locally known as Hulikal Drug.

Rocks in the Penner valley.

The rocks seen in the valley of the Penner are hornblendic semi-granitoid gneiss, much banded and much cut up by numerous trap-dykes, many of them of large size. Many fine examples of river action in wearing and polishing the rocks are to be seen in the bed of the river; but the fall in this part was not great enough to lead to the formation of potholes on a large scale.

Quartzose gneiss north of Honur.

If we turn now north-west across the great Haggari cotton soil plain, we meet with one of the small inliers above referred to, a small hill with a single tree on the top and a very conspicuous object on the plain for miles around. The hill consists of quartzose gneiss, with associated hornblendic gneisses. It might easily be mistaken for an outlier of Dharwar rocks but for the associated gneisses, for it lies in what would be the normal line of extension south-eastward of the Copper Mountain band. This boss of gneiss is not shown in sheet 59.

Bandur gudda dome

Five miles to the westward rises another inlier, the flat dome-shaped granitoid mass known as the Bandur gudda (Bundoor Gooda), a Trigonometrical station 1,659 feet above sea-level.

Two small exposures of hornblendic gneiss within the great black soil plain were noted, the one on the road between Malyam and Honur, a little nearer to the latter place than the half way; the second exposure was on the high ground on the left bank of the Haggari, three miles west-south-west of Honur. Lastly, two bosses of granitoid occur in the north-west corner of Raya Drug taluq, close to the new Bellary-Raya Drug highroad, the one 15, the other 17, miles north of Raya Drug: both are Trigonometrical stations, according to the one-inch Madras Survey map, and have the heights of 1,837 feet and 1,828 feet assigned to them respectively.[1] The northern of these two bosses, Hoss gudda by name,

Hoss gudda boss.

[1] On the northern of these two bosses, I found a fairly fresh and well preserved scale of an Indian manis (*Manis pentadactyla*). I showed it to the people there, but they disclaimed all knowledge of such an animal and denied its existence.

is a banded grey micaceo-hornblendic granite gneiss traversed by several pegmatite veins. One of these, running nearly N. 25° E., had been the cause of the fall of a very large mass of the granite gneiss which had broken away from the rest of the rock along the line of the vein. I had often seen such fractures on a small scale, but never on so large a one: the fallen mass must have weighed many tons.

3. *The Hirahal Sub-division.*—About 2½ west-north-west of the Hoss gudda boss we come across the southernmost rocks belonging to the third or *Hirahal sub-division* of the metamorphic area, the position of which was defined above (p. 30). This sub-division is by far the smallest to be considered. Its northern part belongs to the Hospet taluq and its south-eastern includes the extreme southern end of the Bellary taluq in which lies the large village of Hirahal (Hirrahall) that gives its name to the sub-division. To the south-west it abuts against the Mysore boundary.

A great deal of rock is to be seen, but it presents very few features of any interest or importance.

The low ridge south of the Travellers' bungalow at Hirahal consists of gneiss partly schistose, partly quartzose, and granular in character; but the latter variety does not much resemble the granular quartz beds of Madura district. The gneiss is here overlaid by a thin bed of hornblendic schist, and this, apparently, by grey granite gneiss of the ordinary local type. To the east, this set of beds seems to be overlaid by a banded micaceous granite gneiss weathering of a reddish or brownish grey, the same as seen on the Jazerhalli hill immediately to the south.

Gneiss north-east of Hirahal.

To the north-east of Hirahal several beds of true banded micaceous gneiss alternating with hornblendic schists underlie the Dharwar system with apparent conformity, but it is uncertain whether some of them should not be reckoned to the younger system. I could not satisfy myself completely as to this, but incline to think that the lowest hornblendic schist should be regarded as the basement of the Dharwars.

Green gneiss.

A remarkable gneissoid rock of beautiful green colour, due to cupreous staining, occurs in the corner of the hills three miles east of Hirahal (Hirrahall of sheet 59). Owing to the great extent and thickness of the superficial deposits, talus and soil there occurring, the relationship of this gneissoid rock is open to doubt. In position stratigraphically it appears to belong to the Dharwar system, but petrologically it would seem to belong to the gneisses. Fragments of bright green quartz, derived from this or some other similar bed, are not unfrequently met with on the surface of the great talus shingle bed which lies along the southern foot of the Minchary hills, as the eastern end of the Copper Mountain synclinal ridge is frequently called. This green quartz is often of such rich and pleasing colour that it might well be used for decorative work as mosaic, &c. It was probably from this and from a green gneiss bed near Halkundi, mentioned further on, that the old celt-makers of the Bellary and other neighbouring neolithic settlements derived the green micaceous stone they so much affected in the preparation of "mealing stones," and which they took the trouble to fetch from very considerable distances.

Wilderness south-west of Hirahal.

The rocky wilderness which lies to the south-west of Hirahal is formed of the quartzo-felspathic granite of the group "C" of the classification given on p. 25. It is a rough surfaced (trachytoid), irregularly jointed, small block-forming variety which recurs again largely to the north-west, occupying, indeed, nearly the whole remaining part of the subdivision and making it very rugged and stony.

The felspathic granitoid is largely permeated by small veins of pegmatite, and large portions of the rock itself have acquired a very strongly pegmatoid appearance and texture, but without any visible cause for such change. This feature is frequently to be seen wherever this form of granitoid prevails.

Near the west end of the great Avinmadugu tank is a group of low hills consisting of very fine grained massive felspathic granite gneiss containing black mica.

Hornblendic schist band west of Mallapur.

To the west of Mallapur and about 3 miles west south-west of Avinmadugu is a narrow band of hornblendic schist running south south-east to north north-west in the rough felspathic granitoid with an apparently eastward dip. It is very probably a part of the basement trap-flow of the Dharwar system caught into the mass of the granite at the time of the great crumpling and converted into a schist by the great pressure it underwent. Several similar bands of smaller size appear in the jungly tract further west, but could not be mapped because of the want of landmarks among the low rugged ridges in the jungle.

A traverse of about 3 miles takes one across the belt of trap which unites the Sandur hills and the Copper Mountain ridge, and brings one to the south end of the Hospett sub-division.

4. The Hospett Sub-division.—The first important show of metamorphic rock to be seen here is the Toranagal hill (Tornagul), which is of considerable interest. The hill is a bold, rudely conical mass covered with great fallen blocks on all sides, and consists of an immensely coarse porphyritic hornblendic granitoid, which also occurs to the eastward and in the bed of the Narihalla (the Sandur river) to the west. In his notes on Toranagal hill my colleague, Mr. Philip Lake, remarks: "In many parts of this rock the longer axes of the (felspar) crystals all lie in one of two directions, these two directions being nearly at right angles to each other".

Toranagal hill.

The most strikingly porphyritic part of the rock, as seen on the north-east slope, appears in form of a band considerably darker in colour than the remaining mass of the hill. A similar dark band of extra porphyritic character appears at the eastern end of Kuri Kuppa (Kooree Koompa) hill 3 miles to the north-east; and here the relation of the general porphyritic mass of the hill seems to be that the dark porphyry is a distinctly intrusive mass. This was suspected to be the case at Toranagal, but the evidence was not sufficient to be conclusive.

Kuri Kuppa hill.

The bold rocky hill which rises out of the flat of the great Daroji tank to the north of Kuri Kuppa consists of slightly hornblendic

light grey granite gneiss, of fine-grained texture, showing hardly any trace of bedding.

Daroji hills.

To the north-north-east of this last described hill rise the bold and picturesque Daroji hills, consisting of close-grained pale silver-grey granite gneiss, which is locally much altered, so as to assume a strong resemblance to pegmatite. This applies to the Drug hill immediately west of the village.

Further north the hills consist of coarse moderately porphyritic granitoid.

Newbold's "Intrusive granite".

Newbold speaks of veins of this granitoid as intrusive into the "hypogene schist". This is not the case: the black trappoid rock, which here forms the base of the Dharwar system, rests on the granitoid without the slightest sign of intrusion from its mass; but an intrusive mass of pegmatite lies several yards within the black trappoid; but the pegmatite is quite unlike the old granitoid, and not an irruptive vein from it. Newbold's comparison of this section with MacCulloch's classical section of Cape Wrath in Scotland, is quite unintelligible.

West of Daroji Drug the character of the granitoid is found to have changed to a close-grained speckly grey rock, which may be regarded as an aplite, if the term is applicable to a rock not occurring in veins but in vast masses. Here and there it surrounds small tracts of a highly porphyritic granitoid, which certainly seems to be irruptive.[1]

Gadiganur hills.

Further west in the hills immediately north of the Travellers' bungalow at Gadiganur, the grey micaceous granite gneiss includes numerous bands of horn-blendic schist, which appear to be parts of the basal trap-flow of the Dharwar system which were pinched in at the time of the great crumpling of the peninsula. These bands are of various sizes, from a few yards in length to over a

Included masses of Dharwar age.

[1] The irruptions of these porphyritic granites must have taken place prior to the deposition of the Dharwars, the basement bed of which rests on such porphyry without any sign of intrusion by it (see pp. 137 and 139).

mile, as in the Papanayakanhalli valley, still further west. The immense pressure the trap had been subjected to has here, as in many other places, converted it into schist.

One of these bands of the schist on the Gadiganur hill is greatly cut up, and in some places completely cut off by numerous veins, large and small, or coarse pink or whitish pegmatite running in all possible directions. The veins coincide in some cases with lines of fault which have given rise to dislocations of the general mass of rocks.

North-west of the village of Papanayakanhalli, just referred to, the hills consist of handsome banded grey and white (silvery) granite gneiss.

The Hampi or Vijayanagar hills.

A very great show of granite is to be seen among the hills which surround and rise among the vast ruins of Vijayanagar, the famous old capital of the greatest Hindu dynasty that ruled in the peninsula.

Except in the fine blocky hill crowned by the Martanda Parvatum temple, and in some of the very rugged hills near the eastern gate of the old city, the face of the place has been much changed by quarrying away the majority of the detached and fallen blocks which must have originally thickly strewn the slopes of all the hills. Many of the remaining blocks show the incipient attacks made upon them by quarrymen in the shape of lines of wedge holes that were not utilized.

The vast ruins of temples and palaces which remain show how extensive the quarrying must have been, for almost all the stone used appears to have been raised close by. Exceedingly little foreign stone is to be seen anywhere about the place.

View from the top of Martanda Parvatum hill temple.

From a geological, as well as from a scenic point of view, nothing in this region can exceed in interest the panorama from the top of the Martanda Parvatum. It gives a far clearer idea of the geography of the old city than any amount of study of the official plan can give. The view of the gorge of the Tungabhadra immediately to the north, and of several fine reaches stretching away both north-east and south-west, is most

pleasing. Beyond the river the eye ranges far in a great semi-circle, and takes in the wonderful wilderness of rocks lying to the west and north of the town of Anagundi, where the survivor of the Vijayanagar family lives as a jaghirdar under the Nizam. Though not rich, this scion of a fallen royal family is remembered as such and treated with great respect.

Immediately below the Martanda Parvatum temple the visitor sees a number of narrow but very rich, because irrigated, valleys meandering between the rocky hills, and contrasting their wealth of vegetation with the man-made barrenness of the hills themselves.

The gorge of the Tungabhadra.

In the gorge of the Tungabhadra one cannot help being struck with the enormous force exhibited by the water passing through at high floods. Despite the great hardness of the granite the water has in many places drilled large potholes and worn a very deep cut into the solid rock. At flood times the view of the mighty river forced into that gorge must be something very remarkable and awe-inspiring. The "tumult of the waters" must be something wonderful, probably as striking, though different in kind, as the scene at the falls of the Kistna, so beautifully described by Meadows Taylor in "The Noble Queen".

Outside the actual gorge of the river there is not a trace of water action: all the wonderful rock scenery is due to sub-aërial influences only.

To the south the visitor looks from the top of the Martanda temple across what was the centre of the old city to the towering scarp of Jambanath Konda in the north-eastern wall of the Sandur valley, and his eye rests on a totally different set of rocks, as unlike in colour and disposition to the granitoid as it is well possible for two sets of rocks to be. The Jambanath scarp is perfectly free from fallen blocks such as crowd the hill sides north of the river and give rise to the wonderful screes lying around Anagundi, which must have been a greater protection to the town than the walls surrounding it.

The granite of the Vijayanagar hills is a pale grey when freshly broken, but weathers a pale brownish pink after long exposure. In texture it is moderately fine grained. References to some of the many remarkable buildings, and to some fine monoliths to be seen among the ruins, will be found in the chapter on Economic Geology.

Bookasagra hills.

In the eastern part of the Hampi group, rocks of the same character are largely distributed and form much higher hills west and east of Venkatapur and Bookasagra, where they rise to a height of 2,128′ in the Trigonometrical tsation peak close to Cunnavay Timmapur. They occur also largely in the hills south of the valley leading from Kamalapur to Daroji as far east as Nellapur; but beyond that place the pegmatoid felspatho-quartzose variety occurs, and covers a considerable area to the south of Upparhalli (Ooparhully).

5. The Bellary Sub-division.—This sub-division includes the plutonic and metamorphic rocks to be seen between the Copper mountain band and the Haggari river, from the Tungabhadra south-south-eastward to the great cotton soil spread around the junction of the Haggari and Janagahalla rivers, and which separates the Bellary from the Raya Drug rock areas. Almost the whole of this area is occupied by great spreads of black soil, out of which the granitoid hills rise like so many islands. The number of important outcrops of granite in the sub-division is not very large; but it includes some of special interest, such as the Bellary hills, Kapgal, and the Kurgōd and Tekkulkoté hills.

Bellary hills.

There are few places in the district, with the exception of Vijayanagar, where the rocks can be so well and easily studied as at Bellary, thanks to the great number of quarries which have been opened for local consumption.

The North hill or "Face" hill.

Of the two hills occurring at Bellary, the north hill shows the more porphyritic variety—a coarse "blotchy" felspatho-quartzose granitoid, greyish in colour where freshly broken, with pink blotches formed by included orthoclase crystals, from 1 inch to 1½ inch in length and protruding slightly on

weathered faces. The rock weathers to a dull pale brownish pink. There are no signs of any foliation, but the rock forms a distinct and well marked band, which can be followed several miles to the north-west. Although not foliated on the north hill, the rock of the same band is well foliated in other places, *e.g.*, on the hill north of the jail, where it shows in places a strike of W.N.W. 5° N., the dip being southerly at a high angle. Here, too, the third component mineral is seen to be hornblende. The orthoclase crystals have their axes often across the hornblendic laminæ, or the spaces between them. The hornblendic laminæ are from ½ to 1 inch apart. The rock includes dark hornblendic masses here and there.

Systems of jointing.

The granite is much cut up by joints, and near the western end of the north hill I noted ten several important joint systems[1]; but the general mass of the rock is mainly affected by three systems, one nearly in the line of strike, a second as nearly as possible at right angles to it, and a third very important one, which is nearly horizontal and being very strongly developed in most places, gives a very mural appearance to the hill side where it prevails. Where the horizontal joints are far apart the great blocks formed have a tower-like appearance.

The north hill is very often also called Face hill, because a group of blocks on the highest crest presents from a south-easterly point of view a remarkable likeness to the profile of a human face, the owner of which is on his back asleep. To my eye the profile bears a

[1] They were the following, giving them in the order of observation. Where the angle of dip is not given it was not measurable:—

1. E. 5° N.	— W. 5° S.	dip Southerly.
2. S. W. by S.	— N. E. by N.	„ Vertical.
3. N. 30° W.	— S. 30° E.	„ Easterly.
4. N. 15° W.	— S. 15° E.	„ Westerly.
5. W. S. W.	— E. N. E.	„ Vertical to 80° S.S.E.
6. N. W. by W. 8°—10°	— S. E. by—8°—10° E.	„ ?)
7. N. E. 2° N.	— S. W. 2° S.	„ Vertical.
8. S. E.	— N. W.	„ North Easterly.
9. N. E. 15° E.	— S. W. 15° W.	„ Vertical.
10. The basal joint rolling about locally but approximately horizontal.		

remarkable likeness to that shown in a published portrait of the first Napoleon lying dead (in St. Helena), a likeness which had been recognized before my time. The likeness is best seen in the evening twilight. North hill itself, as seen from the eastward, has a decidedly castellated appearance, and in this respect, as in others, differs considerably from the Fort hill, a little to the south.

The Fort hill.

The rock forming the Fort hill is much less porphyritic in structure, of a lighter grey colour, and in particular not cut up by similar regular master-joints to anything like the same extent. The basal joint is not horizontal, but inclined to be quaquaversal; and hence the general shape of the hill is rather domoid than castellated. On the north-east and part of the north side, the upper part of the hill in particular is covered by a confused scree of huge, fallen, and, generally more or less shapeless, blocks, which is like the screes at Anagundi and Gudikotè already described. On the south-western and western sides, on the contrary, the slope of the dome was too steep for a great scree to remain, and nature has been largely helped by the hand of the quarryman, and the material of which the fortifications have been built have been largely supplied by breaking up the blocks, with the result that the south-western face has been completely bared of blocks. The process of clearing them away is still in progress on a small scale; but the great clearance was evidently made long since, for the scaled face has already been much affected by weathering[1].

The coarser the granite the more deeply will it, as a rule, be found to be weathered. This is certainly the case with regard to the Bellary hills: the coarse granite on the north hill, especially on its northern side, will be found to have been penetrated more deeply by atmospheric action than the finer textured rock of the Fort hill. The

[1] A most amusing, but exceedingly far-fetched, explanation of the bareness of the south-western slope was lately given in a letter to the *Madras Mail*, which explanation deserves, for its absurd ingenuity, not to be forgotten. I give an extract from it in the appendix.

much greater prevalence of joints in the former case has also very largely assisted in the work of destruction.

Water holes on the Fort hill.

Very marked and interesting illustrations of the power of weather action along lines of jointing are, however, also to be seen on the top of the Fort hill in the shape of the water holes which have been utilised as cisterns. In every case the weathering has worked along lines of jointing and produced the remarkable holes which are so useful in holding rain water, and of which the native builders availed themselves so fully by increasing the water-holding capacity by dams.

Some people seem to think the constant supply of water in these holes a rather mysterious phenomenon, whereas it is in reality a very simple one. The several catchment areas which supply the holes are more than large enough to fill them in good rainy seasons, and the larger holes are so deep that their stock of water cannot evaporate more than partially before they get a fresh supply from the skies, and thus never run dry in a normal succession of seasons. There is then no need to appeal to occult causes, such as natural *artesian action, pressure derived from the Copper mountain*, or *subterranean syphons connected with mysterious water stores at unknown depths*, goodness knows where!

Jointing in undecomposed granite.

The depth to which the granitoid rocks are cut up by jointing is a question of some interest, but one on which light is hard to obtain. Judging by the appearance of the jointing seen in the rocky hills, the depth might be supposed to be very great; but this does not seem to be the case everywhere: at least an illustration of this was met with in Bellary itself in December 1885, when the rock-cut basin of the Mainwaring tank opposite the new Collector's cutcherry had been deepened by extensive quarrying, and a large and a perfectly fresh surface of undecomposed granite exposed to a depth of probably 6 to 8 feet below the original rock surface. The hard fresh surface was seen to be traversed only by tiny crannies, barely large enough to be seen, and too small to have their bearings taken accurately, as they did not show for sufficient distances.

Kapgal or Peacock hills.

Less interesting than the Bellary hills, but only because more remote from civilization, is Kapgal, 4½ miles to the north-east by north, a fine bold hill rising 500 feet or more over the plain, and traversed axially by a very large dyke of dioritic trap, which, contrary to the usual rule, has weathered away more rapidly than the surrounding granite, and has in consequence left the granite face against which it once abutted standing as a fine cliff from 80 to 100 feet high, which dominates the east end and forms a very conspicuous feature from the eastward.

The Kapgal rock is very like the Bellary granite, and the Sungankal group of hills to the south of it must also, I think, be reckoned as part of the same band of rock. The horizontal jointing is very strongly developed on Kapgal, producing the usual mural effect, and giving rise to the formation of many rock-shelters, which afforded good shelter to the celt-making people of early times, who had a large and important settlement on the hill, and carried on a considerable celt-making industry, using the trap rock they found in the great dyke above referred to. Some of the best rock-shelters are at the very top of the hill among the huge blocks which form the actual summit.

The summit affords a good illustration of the formation of extra large blocks, almost tower-like in shape, by the unusually great apartness (if the word be allowable) of two of the great horizontal joints.

Masking of the surface by the black soil spreads.

It is in the Bellary sub-division particularly that one becomes alive to the great hindrance in working out the extent of the several rock groups, and their inter-relations that is caused by the cotton soil spreads which intervene and cover up completely so great a portion of the surface. You may often pass over several miles of the black soil without meeting the tiniest outcrop, or the outcrop may be one of uncharacteristic rock, or of rock too decomposed to be recognizable with any certainty, or of rock which may be doubtfully *in situ*.

Thus I believe that the Bellary and Kapgal rocks belong to one

great band of granitoid stretching away roughly north-west and south-east for many miles; but although I made a pretty close net-work of traverses in that part, the evidence I got together was insufficient for me to venture to map such band as an established fact. To work out the details of the metamorphic country under existing circumstances would involve several more years of hard work—work interesting on petrological grounds, but utterly useless economically, unless some enthusiastic petrological amateur should arise in Bellary who would and could devote unlimited time and patience to piecing together the very scrappy information; but I believe even he would fail and give it up in despair, seeing the immense amount of uncertainty that must prevail as to extensions of bands of varying rocks when so very little is really to be seen.

Kurgod hills.

The most important show of granite to the north-north-west of Bellary is that forming the Kurgod hills, a group of detached hills crowded together in a rather circular cluster, about 4 miles in diameter: they are all very similar in appearance and consist of massive grey micaceous granite. The hills are very blocky and consequently hard to climb.

Where freshly broken the rock is a bright, almost silvery grey. In a quarry near Waddahatti, in the same band of rock, but a little south of the hill group, the stone, a very handsome one, quarried very kindly. The rock is often to be seen weathered to great depth, but this must be the work of a great lapse of time; for, judging by the condition of the walls of sundry temples and of the old fort on the Kurgod hill itself, the stone seems a very durable one.

Some of the lower hills show very markedly the bare piles of confusedly fallen blocks, the "screes" so characteristic of some of the hills in the neighbourhood of Raichur and other places further west in the Raichur doab, and also of some of the hills in the Gudikoté group mentioned at page 43.

The pale grey colour of the fresh rock is seen wherever it is exposed in quarries.

The Kurgod band extends both north-westward and south-east-

ward, but is eventually lost under the black soil in each case. Its relation to the Bellary-Kapgal band is nowhere revealed: they have not been seen in contact.

Red granite at Dammur and Bailur hill.

At Dammur, 10½ miles north of Bellary, is a patch of vividly red granite of uncertain extent, it being quite surrounded by black soil. The rock is a massive one of great beauty. It is covered up on the east by the edge of the Pennér Haggari Dharwar band. To the west it is speedily lost sight of under the black soil. To the north similar red granite is seen along the base of the Sindigiri Hæmatite hills near the village of Kanchigiri, also intermediately to the south of Bailur (Byloor), where it forms a moderate sized hill. The ferro-magnesian constituent of the granite is a decayed greenish mineral; but whether of micaceous or hornblendic origin could not be ascertained from mere eye examination.

Sirigiri hills.

Five miles due north of the Kurgod hill group lies the Sirigiri clump of granite hills, which offer no feature worthy of special notice; but the plain to the south-west and south of them is remarkable for its rocky ruggedness on a small scale.

Shid Rampur hill, a little east of Sirigiri, shows a very fine scarp and bluff at its northern end.

Tekkulkoté hills.

To the north-east by north of Sirigiri, at a distance of 5 miles, lies the Tekkulkoté group of granite hills, the southern point of which rises to a considerable height above the plain, and must be very close upon, if not over, 2,000 feet above sea level. The hills consist of grey non-porphyritic granite weathering variously greyish brown, pinkish, or brown. Several of the hills are omitted from sheet 58.

The hills form a fine group: they are bold and well-shaped, and show many fine blocks and tors. Of the latter, one on the south-western spur of Tekkulkoté gudda, as seen from the north by morning light, has the exact shape of a huge bear sitting upon his haunches.

Hardly to be considered as a separate group are the hills at and around Halakoté (Hallakota), which consist also of pale grey granitoid, perhaps rather more dense in texture. The rock freshly exposed in the quarry in the hill immediately east of the high road at Halakoté is of a felspatho-quartzose variety, with mica for the ferro-magnesian element. The lamination is obscure, but a great joint plane with a low southerly dip gives a strong appearance of bedding. This same nearly horizontal joint-plane gives this hill in particular a very mural appearance as seen from a distance from the north.

Halakoté hills.

These hills appear to be a direct continuation of the great band running north-westerly across the Alur subdivision next to be described. The band is again continued north-westward from Halakoté and crosses the Tungabhadra at Kenchengod, to reappear in the very picturesque Salgundi hills in the Nizam's territory, and to be finally lost under the cotton soil after forming the bold Rawalkonda (Rawducoonda) mass.

Extensions of the Halakoté hill.

At Siriguppa, and to the east of it near the Rarevi ford over the Haggari, the prevalent rock is a hornblendic granitoid. Returning southwards, past the Tekkulkoté hills and along the left (western) bank of the Haggari, only a single really notable outcrop has to be recorded, and this is the Gudadur hill, 12 miles north-north-east of Bellary. The hill, which is a low one, consists of highly quartzose granite, supporting beds of not very rich magnetic iron associated with a pink felsitic gneiss, both much contorted. Whether the position of the iron and felsitic beds to the granite be one of unconformity, or of conformity, it is hard to tell for certain, the evidences are if anything in favour of the latter position. In a gully north-west of the hill another very small magnetic iron bed is seen to be distinctly intercalated with the granite and in no wise metamorphosed, as if the latter had been intrusive.

Magnetic iron beds of Gudadur hill.

South of Bellary the grey granite extends for two or three miles, and after a break of a mile or so, a belt of banded granite gneiss is entered upon, which

Hálakundi gneissic band.

runs rudely parallel with the Copper Mountain range, and in apparent conformity with the synclinal formed by the Dharwars. One of the best outcrops of this gneiss band is to be seen in the small Hálakundi hill, which consists of banded hornblendic gneiss of grey colour with a south south-west dip, and showing much crumpling in parts, beside being much cut up by numerous small greyish white granite veins running in different directions.

Six miles east south-east of Hálakundi similar hornblendic banded gneiss crops out between Ibrahimpur (Ebrampoor) and Yettan Budihal. Further south, close to the extreme south-east point of the Dharwar rock area, is a show of pale grey compact micaceous gneiss.

To the south of the Mincheri hills, (the east end of the Copper Mountain range), the gneissic band is very doubtfully represented, the rocks being more granitoid in character.

Gneiss inlier in the Dharwars.

A singular inlier of micaceous gneiss, grey in colour and highly crystalline in texture, appears standing up among the hornblendic schists south of Chennur royankoté. The mass, which has been exposed by the denudation of the Dharwars, is about 300 yards in length by 100 in width, and shows a dip of 50° to 60° (estimated) to E. 10° N.

Belonging to the gneissic band is a show of pink felsitic gneiss noted as occurring south of the bridge which crosses the big nullah which drains the eastern slope of Suggalamma Konda (Sugadevibetta)—*anglicé*, the Copper Mountain.

Green gneiss.

In the spur which descends north-eastward from the Copper Mountain the banded gneiss becomes locally very granitoid, but in other parts the gneissic character prevails. In one place on the northern slope of a branch spur, the gneiss is stained a very pretty green by the presence of a small quantity of carbonate of copper. This staining affects only a narrow band which lies in the general strike of the rock to the northward of the great trap dykes which cut across the spur.

6. The Alúr Sub-division.—This sub-division, which nearly coincides in shape with the Alúr taluq, is bounded on the west by the

Haggari river; on the south by the Anantapur District coinciding very closely with the Bellary-Kistna Railway as far as Guntakal Junction; on the east similarly by the Madras Railway as far as Nagarur station. From Nagarur station the boundary must follow the valley of the great Harivanam nullah north-westward till it makes its great bend to the north; and thence the boundary must be run across westward to the confluence of the Haggari with the Tungabhadra.

Area much masked by black soil.

As in the case of the Bellary sub-division, by far the largest part of the area thus defined is masked by great spreads of cotton soil, and important exposures of rock are few and far between, and mostly wanting where most required to elucidate the structure of the country. Owing to this the geological interest in this sub-division centres almost entirely in the Alúr group of hills, which occupies the middle of the sub-division. From it extend respectively to the west north-west and south-south-west two lines of hills, and beside these there are only seven or eight prominences in the area to which the name of hills could be applied.

The Alúr hills.

The Alúr hills form in plan a pointed oval, the point lying to the west north-west, in which direction they measure about 9 miles, and about 7 at right angles across the widest part of the group. The highest point is the summit of the Arrakera (Urrakaira) hill, 2,127′ above sea level and about 700′ over the adjoining plain.

The prevalent rock is a hornblendic granitoid, generally banded. The surfaces are but moderately blocky, and grey is the almost universal colour of the freshly broken rock. Small veins of epidote (pistacite) are very common, and so also are veins of pegmatite of white or pink colour.

Malleshwaram gudda (not shown in sheet 58), the centre of the western part of the group, is quite as high in appearance as Arrakera hill, and a much finer mass and far better worth climbing, the western part being far more picturesque and better wooded; less bared of wood would probably be more correctly descriptive.

Of the hills forming the north-western extension little need be recorded but that some beds of micaceous rock are associated with the predominantly hornblendic variety. The granitoid rock shows much alteration in contact with the immense quartz runs which form a triple crest to the Siddapan Konda ridge, but unfortunately the change has resulted in the altered rock being seen only in a state of advanced decomposition and unfit for further examination. The quartz rock being quite unused, no quarries exist in which the altered rock might be seen in a less advanced state of decomposition. There can, I think, be no doubt but that the quartz runs were irruptive and not segregational in their origin.

Contact metamorphism along the great quartz runs.

The rocks to the east and south of Alúr village, the Kasba of the taluq, are everywhere the hornblendic granitoid, with much pistacite in veins.

Pistacite veins.

The veins of pistacite are of all sizes from the merest threads hardly perceptible to the naked eye, permeating the rock in various directions, but generally parallel to some great line of jointing up to veins several inches thick. Occasionally veins some feet in thickness are met with, and Mr. Lake, in his notes, mentions one (occurring a little to the north-west of Molagavalli, about 7 miles east-south-east of Alúr) "some scores of yards across," but very ill-exposed, "so that its precise thickness could not be determined".

The pistacite is generally of a bright yellowish apple-green and highly crystalline, forming a mineral of great beauty which is further set off when, as is often the case, "the veins are bordered by a zone in which the felspar of the gneiss or granite has been stained dark red" (deep salmon pink). "The colour is deepest close to the epidote and gradually fades away as the distance from the vein increases". (P. Lake, Notes). Grains of pistacite are frequently scattered through the matrix, but generally in the close vicinity to veins of the mineral.

To the east and south-east of Alúr are some of the largest and most unbroken spreads of black soil in Bellary district. It frequently happens that, for distances of 6 and 7 miles at a stretch, the sub-rock is

utterly hidden, and then, if a little outcrop does show in the dry bed of a stream, the chances are ten to one that the rock is too much weathered to be safely recognized: its original character can only be guessed at.

Ram Drug.

One of the chief shows of rock south-south-east of the Alúr hills occurs at Ram Drug (Ram Doorg), 11 miles north-west of Guntakul Junction, a fine bold sharp-peaked hill, rising some 600 feet above the plain and 2,029 feet above sea level. In the north spur, the rock is a fine grained grey granite cut up by many veins of a younger granite, also by veins of a felsitic mineral, and it shows also much coating of joint surfaces with pistacite.

The neighbouring hills of Naggaradoni, Sangala, Beldoni, and Chippagiri are all granitoid, but without a special distinguishing feature. To the south of Chippagiri hornblendic granite shows near the Bantanhal railway station.

Virapur station hills.

The hills at Chakibanda (Chaukibunda), those north of Virapur station and Karakal hill, rather further to the north-west, form an extension of the Guddakal ridge in Guti taluq, of a generally highly felspathic rock which ranges in appearance from a fine grained felsite, through a pink felspathic gneiss to a rather coarse highly quartzose granite. Its texture is very variable, and it is cut up by very ill-developed systems of jointing, so that its blocky surfaces are remarkable for the shapelessness of the blocks covering them, which produces an effect of great untidiness and shabbiness.

Sindaball hill.

Some 8 miles to the north by west of Karakal a low ridge of coarse hornblendic (?) gneiss crops up close to the Tungabhadra at the village of Sindavalam (Sindaball), an extension probably of the rocks near Chinta Kunta. Sindaball hill, and a much higher very striking hill, two miles to the north-east, are both omitted from the map. The latter shows a highly felspathic variety of hornblendic granite.

New Guliem syenite hill.

A little more than 1½ miles to the north-west of the latter rises a small very steep-sided hill (not in the map), which consists of red syenite (? hornblendic

granite). The hill is about 120 feet high. Immediately to the west of it lies the new village of Guliem (Gooleum) built here after the destruction of old Guliem by the great flood of Haggari in 1851.

Leaving the Alúr group, nearly all the outcrops noted to the northward are of hornblendic granite, very rarely of gneiss, and this holds good up to the extreme north end of the Alúr sub-division at the bend of the Harivanam nullah at Gubihal.

7. The Adoni Sub-division.—This sub-division, as above delimited, corresponds almost absolutely with the fiscal limits of the Adoni taluq, which has one natural boundary—namely, the Tungabhadra—along its whole northern side. The south-west boundary is an approximately natural one—the Hira Harivanam nalla—while the south-eastern one is purely a fiscal one, separating it from Kurnul district. Only the southern central part of the sub-division is hilly, and only in the north-western part have a few scattered hills to be described; the extreme western, the northern, and north-eastern tracts are quite devoid of hills.

The hills may most of them be included in four groups: the Adoni group, the Kamana Konda group, 11 miles north, the Kotakal group, 7 miles to the east, and the Emimganur group, 6 miles north-east of Kotakal.

The Adoni hills.

The Adoni (properly Advani) group forms a very fine mass lying north of the well-known town which gives it its name, rising in a very bold scarp all but 700 feet out of the plain, which itself lies 1,300 feet above sea level. The highest part, which is covered by the ruins of the famous old hill fort, lies immediately north of the town, and is well worth climbing for the beautiful rock scenery close at hand and the fine panoramic views all around. Even yet finer views are to be got from the high rocky peak marked in the map as "station," which lies a mile to the eastward of the old fort and overlooks both it and the fine tank lying between.

The general colour of the very massive rock is grey, but in parts it varies to pinkish grey and rich purple, also to greenish, all

susceptible of very high polish, and thus of furnishing stone of exceeding beauty for decorative purposes. The granite is in parts hornblendic.

The Adoni group measures 8 miles in length by 4 in breadth at its widest just north of the town. The longer axis runs about west by north: here and there, at rare intervals, the granite shows a bedded structure, as to the eastward of the eastern trigonometrical station just referred to, and again at the northern extremity of the great northern spur descending from the summits of the Drug hill. Here the quasi-bedding is strongly developed, and shows a dip of from 50° to 60° E. by 5° S., the strike being in both cases N. 5° E.

The great south scarp shows a rather striking system of jointing on its face, which has to some extent affected the weather action on the exposed surface, and shows up very conspicuously in a kind of net-work pattern. The place is utterly inaccessible, however, and the joint system cannot be determined.

Rain grooving of rocks.

The bare face of the rock is much grooved by the direct erosive action of rain. I had been inclined to attribute much of this grooving, which is a very common feature on bare granite rock surfaces, to inequality in the resisting power of the rock connected with the quasi-banded texture so often prevailing even in typical granites, but afterwards came to the conclusion that it resulted largely from direct mechanical erosion, by rain, from watching the effects of a very violent thunder shower which fell just within the limit of the summit plateau. The sun was well over to the westward, and lit up the storm and the face of the rock in a wonderful way. The summit plateau at the point I was watching is practically a bare sheet of rock; but for a few minutes all the water which rushed over the scarp in large quantity was quite turbid, but then became quite limpid, and continued so to the end of the storm. The whole face of the scarp was for the time swept by a violent current, which only wanted volume to become immensely destructive. The utter bareness of the rocks could be wondered at no longer.

In the centre of the group the blocky form of surface does not

prevail, but it increases to the northward and becomes conspicuous on some of the spurs.

Minute faults and dislocations.

Signs of the disturbances and strains to which the rocks have been subjected subsequent to their original formation are to be seen occasionally in the form of systems of small dislocations and faults. An interesting example of such was pointed out to me by my colleague, Mr. Lake, on the spur east of Isbee (2½ miles north-west of Adoni).

Extensions to the north-west.

As extensions of the Adoni group to the north-north-west may be reckoned the detached hills at Yerragiri, Vurakonda (Oorkoonky), and Halvy (Hallwy), all three of which belong to a micaceous band. Vurakonda shows some of the finest masses of granite that I have ever seen. Their size is simply gigantic, and the whole hill, though by no means a large one, is most striking and picturesque.

Halwy hill.

Halwy hill, too, is a fine object and very conspicuous, as it towers up at the edge of the Tungabhadra alluvium. The hill is partly gneissic, partly granitoid. In the gneissic beds, which strike N. 5° to 7° W. with a high westerly dip, black mica (biotite) often abounds,[1] and many examples exist of minute faulting, such as were seen on the Isbee spur near Adoni, and were referred to above.

The country lying west of the line of extension just mentioned is very flat, the rolls between the different stream valleys being very low, and entirely covered by black soil. Outcrops of rocks are very few and far between and of no special interest. They are mostly of the hornblendic variety.

Extensions to the south-east.

The south-easterly extension of the Adoni group shows many picturesque hills which belong to the castellated and pinnacled types rather than to the blocky, but they present no features requiring individual notice. Tengul-

[1] As a rule, in the granites and gneisses of this part of the district the ferromagnesian constituent of the rocks, whether hornblende or mica, plays a very subordinate part.

dodi hill is perhaps an exception on account of the very fine rocky bluff at its southern end.

Kamana Konda hill.

The Kamana Konda group, north of the Adoni group, offers a characteristic difference in appearance from the latter. Blocky hills are one of the most striking features of this group instead of being of rare occurrence. Some of them, such as Kosgi hill, are among the most striking in any of the granitic districts of the peninsula. Kamana Konda shows a good number of fine tors, and

The "Sisters" tor.

to this group belongs also what I regard as the finest tor known in South India—a rock called by the natives the "Akka chellulu"—the "Sisters"—a pair of tall thin blocks perched on the top of a huge tower-like mass: the height of the whole I estimate at about 80 feet. From certain points the rift between the two uppermost blocks opens sufficiently for day-light to be seen between them. The "Sisters" are situated a short distance west of the railway, about 3 miles south of Kosgi station.

Kosgi hill screes.

Kosgi hill, already referred to as a fine specimen of the blocky-surfaced hill, is between 400 and 500′ high, and its whole surface thickly covered with large weather-rounded blocks in utter confusion, as if they had not only fallen out of *situ* through weather action, but as if they had afterwards been further well shaken together and out of all possible relation with the former joint systems which had allowed of the weather acting upon them. Such shaking was undoubtedly done by severe earthquakes, though even slight ones must from time to time shake down large blocks and tors, which have come to be weathered into states of precarious equilibrium. I have elsewhere called such confused blocky surfaces "Earthquake Screes", for screes they undoubtedly are, and nothing else, though on a gigantic scale, and so they had better be called for the future "Giant Earthquake Screes". See page 43.

The Kotékal group of hills must now engage our attention: they are too well-marked and important a group to have been treated only as an extension south-eastward of the Kamana Konda group, though from their geographical position that might have been

thought sufficient. Their greatest length from south-east to north-west is nine miles; their greatest width about two. The highest point at the south-eastern end is about 500 feet above the plain, and they most certainly deserve to be described as bold and picturesque. Owing to the presence of much horizontal and vertical jointing, many parts of the hills present castellated features which are always pleasing.

Kotékal hill.

The grey generally porphyritic granite of the Kotékal itself (the "Castle hill") overhanging the village of that name is very much banded and foliated, even where porphyritic, when the crystals of orthoclase are disposed in lines. The banding is mostly vertical or has an easterly dip at a very high angle. The castellated structure shows very strongly at the south end of Kotékal hill itself, and it wanted but a few walls to make it a strong fort in olden times.

Arkal hill.

About a mile west of the Kotékal hill and close to the high road to Adoni rises a small hill, Arkal (Argul) by name, made of very porphyritic purplish pink granite with large well-marked rosy crystals of orthoclase on the western side of the hill. On the east side the porphyritic structure is less marked and some foliation is to be seen. The rock has weathered into very large blocks, which form many rock shelters that are still used by the people of the little village built up the southern side of the hill. Several were in use as stables and one as a blacksmith's shop. They had previously been in use by pre-historic people,

An old pre-historic site.

of whose residence various traces remain among the rocks around the village. At the time of my visit a very large and efficient chamber formed by a huge flattish mass, resting its ends on some smaller rounded blocks, was largely resorted to by travellers along the road, as a large toddy shop was kept there and was doing a brisk trade. As I watched the crowd from the top of the hill while resting for a little, I could not help speculating whether this remarkable rock chamber had been put to similar uses, by the neolithic folk, as from its proximity to the pass through the hills

there might well have been a much-frequented path there. There was no conclusion to be arrived at then; but, from a discovery I since made at a pre-historic site in Cuddapah district, I think it is extremely probable that the preparation of palm toddy was known in very early times.

Between Kotékal and Emmiganur (Yemmiganoor), the country rock, to use a mining term for convenience and brevity, is everywhere granitoid with red soil on it.

Four miles to the north-east of Emmiganur the rock to be seen is a typical porphyritic hornblendic granite of dark grey colour, but weathering pink in parts. This is to be seen west of Timapur. A great show of granite is to be seen on the plain around Garladinni (Gardinna of map).

Timapur.

Granite is also to be seen in the bed of the Tungabhadra, eastward of Nagaladinna (Nagul-dinny).

Granite at Nagaladinna.

At the bend of the river, 3 miles east of Nagaladinna, is a show of coarse hornblendic granite containing also some plates of biotite. A very similar looking granite which occurs west of Timandodi (close to the boundary between the Bellary and Kurnul districts) shows on breaking no hornblende at all, only biotite (black mica) in large proportion.

The country along the Tungabhadra is covered almost everywhere by black soil, which forms a band from 7 to 8 miles wide on the average. The regur being, as a rule, very thick, outcrops of rock within its limits are few and far between.

To the south-west of Nagaladinna, in a little nullah which rises south of the village, is a show of black hornblendic schists, which are continued westward and associated with a band of red felsitic-looking gneiss. This is again succeeded by a great thickness of the black hornblendic schists, which may be followed for fully two miles. There is nothing whatever to show the real age of this patch of schists, but they do not resemble the Dharwar schists. On the contrary, they have a decidedly

Hornblendic schists near Nagaladinna.

more ancient looking facies, and I am in favour of regarding them as of the age of the archæan gneiss. At the time of my visit the Tungabhadra was in flood, and I could not make out for certain whether these schists cross the bed of the river into the Raichur Doab. They have a strike of N. 5° to 10° W. with a doubtful dip.

Hornblendic granite west of Manchal.

Westward of the schist band appears a typical hornblendic granite largely developed and well seen. It is of a dark purplish brownish grey in colour. The next important outcrop westward along the Tungabhadra is a micaceous banded granite gneiss, which extends far up the bed of the river from the village of Manchal (nameless in sheet 58).

Granite near Nandivaram.

Seven miles south-west of Manchal is a great development of granite in low hummocky masses to the south and south-east of the large village of Nandivaram. Four miles to the north-east of Nandivaram is a group of tors, the central one of which is a fine tower-shaped block, some 30 feet high, and a striking object on the black plain.

The Emmiganur group of hills.

Not quite 7 miles south-west by south of Nandivaram, overhanging the village of Murvani, is the very picturesque fort-crowned hill of the same name, which forms the western end of the Emmiganur group of hills. The hill consists of a seemingly hornblendic granite, probably the same as forms the big hill to the south-east, which is an unquestionably hornblendic granite. In both these hills the horizontal joint series is largely developed, and the castellated structure consequently well shown.

Kaddimetta hills.

In the eastern hills of the Emmiganur group pale grey micaceous granite is largely developed. In parts much banding is seen, but it is not general. The Kaddimetta (Kuddametla) hills, 4 miles east-south-east of Emmiganur consist of moderately fine band grained porphyritic hornblendic grey granite, in which both the felspar and the hornblende show distinct and shapely imbedded crystals, the former pink, the latter dark green or black.

CHAPTER V.

THE LOWER TRANSITION, OR DHARWAR ROCKS.

This great system of submetamorphic sedimentary rocks, with numerous contemporaneous trap flows, was not recognized as distinct from the South Indian gneiss till the geological survey had been extended by me across the Raichur Doab, and the south of Belgaum and the centre of Dharwar district visited, together with parts of Bellary and Mysore. Newbold had included it among his "hypogene schists", which he thought had been broken through by the granitoid rocks which form so large a part of the Bellary district and adjoining parts of the Deccan plateau. Herein he was mistaken, for the granitoids, as a whole, are much older than the Dharwars and form the base on which they rest. Only a few veins of pegmatite are intrusive in the Dharwars, and these he appears to have mistaken for intrusions emanating from the general granitoid mass, whereas they are really of post-Dharwar age.

Hypogene schists of Newbold.

The greater mass of the Dharwars consists of schists, hornblendic, chloritic, and argillaceous; but the associated traps, and more especially the hæmatitic quartzites, from their superior hardness and durability, occupy in many places much the most prominent positions; while, from the same reasons, the taluses they have given rise to in the hilly tracts are of extraordinary extent, and cover up much of the softer rocks and mislead one as to their real extent.

The Dharwar rocks were originally deposited over very much larger areas than those they now occupy, and very probably extended across the whole, or nearly the whole, peninsula. How far they may have extended to the north it is not possible at present to say, for the northern extremities of several of the Dharwar tracts are hidden under younger geological formations, *e. g.*, the Kaladgi and Bhima series, and the Deccan trap along the upper course of the Kistna river. To the

Original extent of the Dharwar rocks.

southward the Dharwar rocks extend into and across the valley of the Kavéri almost to the northern slope of the Nilgiris. The distance between the southernmost and northernmost points at which Dharwars are known to occur is over 300 miles, while from west to east, measured in latitude N. 14°, the area occupied by the Dharwars is rather over 200 miles in width. The Dharwar system was exposed to great contortion and deformation at a very remote geological period, and this had been followed by a vast period of denudation, during which the enormous folds into which they had been forced previously were largely eroded, and cut up into the great bands in which they now occur. In general structure these bands are of two types—in the one, the band is a narrow synclinal fold, or a series of narrow synclinals echeloned after each other at exceedingly acute angles. In the second type, the band shows a natural erosion boundary on one side, and, on the other, is faulted down against and among the underlying granitoids. It is owing to these faultings down into the older rocks that the softer schistose members of the system have in many cases escaped from being entirely denuded away.

Erosion into great bands.

Four of the numerous bands in which the Dharwar rocks are disposed about the Southern Deccan lie within the limits of Bellary district, and all extend across it in a more or less south-easterly direction. The bands here represented are, taking them from west to east, the following:—

1. *The Dharwar-Shimoga band:* the eastern side of which crosses the Tungabhadra a little below its junction with the Warda, in the Dharwar district, and runs southward some 25 miles nearly parallel with the general course of the Tungabhadra till it crosses the Mysore boundary a little north of Harihar railway station. This tract, which measures about 190 square miles in extent, I shall, for brevity, designate as the *Kunchur*[1] (Coonchoor) *tract.*

[1] In my paper on the Dharwar system, which was published in the Records, G. S. I., Vol. xxii, 1888, I referred to this tract, of which I had then only seen the northern extremity, as the "Kunchur outlier", under the impression that it was an outlier which it seemed to be as seen from the top of the Birrabi hill.

2. *The Dambal-Chiknayakanhalli band.*—This band crosses the Tungabhadra and enters Bellary district at the picturesque gorge of Honnur, 4 miles west by north of Huvina Haddagalli, and leaves Bellary district soon after crossing the Chikka Haggari river, some 35 miles to the south-east. For the Bellary section of this long band of Dharwars, I propose the name of "*Mallapan gudda band*," after the fine peak of that name, which forms the summit of the range of hills occupying the centre of the band between the two rivers just named. The area of this band is just over 140 square miles.

3. *The Sandur-Copper mountain band.*—The most interesting and extensive of the Dharwar areas in Bellary district, having an area of 360 square miles in round numbers.

4. *The Pennér-Haggari band,* which enters the Bellary district at Naddevi on the Tungabhadra, and runs for nearly 40 miles south-eastward, when it passes into Anantapur district.

1. *The Kunchur tract.*—The eastern, central, and southern parts of this tract are hilly; the remaining parts are open rolling plains. For convenience in description, I will divide the tract into two parts: one north and north-west of Kunchur village; the other to the south of it. The eastern boundary of this tract is an erosion boundary in most places, and there can be no doubt that it was formerly connected with the Mallapan gudda band by a wide anticlinal arch, the crown of which has been removed by denudation.

The hilly parts which occupy the eastern, central, and southern parts of the Kunchur tract owe their elevation mainly to the presence of a large number of important beds of hæmatite quartzite, which resist the action of atmospheric agencies far longer than do the softer argillites and schists, which occupy nearly all the level country. The argillites crop out in many places and roll about a good deal on a small scale and often present a very confused arrangement, which makes it hard to understand their relation to the other members of the series. Not a single good continuous section of any length was met with.

In the northern part of this band the hæmatitic beds lie near the

base of the series ; the lowest of them rests on red (hæmatitic) argillites and green and grey schists. The crest of Kalhalli gudda,[1] the highest point in the band, is formed by two great hæmatite quartzite beds lying somewhat higher in the local series, and dipping westward at an angle of about 60°. A little more than a mile north-north-west of the peak the beds make a short sudden bend from the north-west by north to north-east by north, and are cut off by a fault which makes them abut against the granitoid at foot of the ridge, which here terminates in a very abrupt slope. A lower ridge branches to the north-north-west and extends along the eastern boundary of the band, trending gradually to the north. Several considerable beds of hæmatite quartzite occur in this ridge and form parallel crests along it.

Kalhalli gudda hæmatite beds.

Their southerly course trends westward from opposite the Kalhalli peak, and they cross the Tungabhadra at Karabagaddi (Currabguddy) nearly 8 miles to the south-west, and then immediately trend north-west and again west, disappearing (dying out?) on the right bank of the Tungabhadra at Hira Kuravatti. The hæmatites are thus seen to form in plan a rude horse-shoe open to the north-west and having its apex at Kunchur, where the lowest of the beds runs under the village, after forming a bold rocky ridge which sweeps down from Kalhalli gudda. The bed may be followed for some 3 or 4 miles south-west from the village, but then dies away under a great cotton soil spread. As seen in the low hills south-west of Kunchur, the rock is extensively brecciated. As a glance at the map will show, the west side of the horse-shoe is much the least developed.

Karabagaddi hæmatite beds.

In the centre of the horse-shoe is another series of good-sized hæmatite quartzite beds which form a shallow horse-shoe curve open to the north. Their stratigraphical relation to the apparently underlying beds of the Karabagaddi beds is obscure. Still more obscure is the relation of the great bed forming the ridge south of Yharada.

[1] Kalhalli gudda (Cullhully gooda) is the second highest peak in the western taluqs, the highest being Mallapan gudda, 11 miles to the north-east, which attains the height of 3,177 feet.

A system of faults will doubtless account for its anomalous position, but they are not obvious on cursory inspection, and they will have to be worked out by some future observer.

No discrepancy appears to exist between the Kalhalli gudda and Karabagaddi beds, and if their sequence is a true one they must represent a series more than 12,000 feet in thickness.

Hollāl argillites.

The rocks forming the north-western part of the Kunchur band, and which are largely seen in the plains around Hollál, consist almost entirely of grey and greenish grey argillites, which on the surface are soft and of shaley consistency and appearance. Whether they are much harder in depth I cannot tell, for, being utterly useless for building stone of any kind, no quarries exist in which unweathered parts are exposed to view, and their relations to the other members are obscure; but, as far as can be seen, they form the uppermost division of the Dharwars in this region of the rocks which are exposed to view. They roll about a great deal on a small scale, but are very badly exposed. They give rise to an open undulating country much covered with cotton soil and singularly bare of trees through human agency.

To the south of Kunchur in the southern part of the band we meet first with a belt of schists and argillites, between 2 and 3 miles in width, and, apparently, underlying the Kunchur hæmatite bed. A large exposure of green and slate grey schists is to be seen to the north of Nattur (4 miles south-east of Kunchur), where they dip north-west from 50° to 60°.

South-east of this schist belt rise some hills about 300 feet high, which are crested by two or three moderate sized hæmatite bands, which have a southerly course for about four miles and then sink down into the plain, the hæmatite bed disappearing at the same time. Here, too, it was impossible to ascertain the positive relation of these beds to those at and north of Kunchur. It is hard to imagine that they really underlie the northern beds in true sequence and form a series of such enormous thickness as that would constitute; the probability is they

Relation of the Teligi and Kalhalli gudda hæmatites.

are part of the same series reproduced by great faulting. This explanation will, I think, hold good also for the great hæmatite beds still further south in the Teligi hill, and to those westward of it, forming the Vatala-halli hill (Wattlehully) on the right bank of the Tungabhadra. These latter appear to cross the river valley and to reappear in the hills, which rise in Dharwar district between the river and the town of Rani Bennur.

Teligi hill.

The triple hæmatite bed which forms the Teligi hill probably occupies a higher position in the series than those cresting the hills north and south of Hallagilvadi, which later re-appear further south in the great bed which forms the crest and peak of Kondaji hill and extends southward for several miles into the Mysore territory spread. None of the hæmatites present any features of special interest; many of them are rich enough to be worth smelting if fuel were cheap and abundant; but the hills of the Kunchur (Coonchoor) band are very bare of vegetation, and the argillite plain still more so, though perfectly capable of supporting fine trees. I did not hear of any existing iron industry in the Kunchur band, nor meet with signs of an old iron industry, except in the form of an old mine of no great size, on the north-west side of Teligi hill. This mine will be referred to again further on.

Beds west of Teligi hill.

East of the old iron mine at the north-west end of the Teligi hill are two dark black parallel ridges, which at a little distance, look exceedingly like trap-dykes, but when closely inspected they turn out to be hæmatitic beds and extensions of the Vatallahalli hæmatites. They are composed of hæmatite quartzite greatly crushed and brecciated, and have undergone much laterization of the surface, which is also largely coated in parts with brown hæmatite.

Pink and lavender argillites.

Some of the argillites overlying the Teligi triple hæmatite band are of pinkish and lavender colours, soft in texture, and suitable for pigments. These seem to have been excavated from the old mine, as well as the locally soft and rather clayey iron ore. They show, too, in some deep rain-gullies on the

slopes of the hill. The low hills south of Yerrabal (Yerrayball), which are not shown in sheet 59, are crested by short and rather ill-defined beds of hæmatite. They dip under the thick argillites exposed in the Yerrabal nullah banks. Whether these argillites belong to the same series as those north of Nittur and in the Kunchur tank flat is uncertain owing to insufficient sections.

Pencil quartzite.

The summit of the hill south of Hallagilvadi is a not very rich hæmatite-quartzite, considerably contorted, and the silicious laminæ of which, where rather thick, assume a remarkable stalky or "pencilled" structure at right angles to the bedding. The base of the Dharwar rocks at foot of this hill is a rather schisty slightly micaceous quartzite. A similar rock forms the true base of the Dharwars east of Teligi hill, and is overlaid by a considerable thickness of hæmatitic and chloritic schists. Underlying the great hæmatite bed which crests the Kondaji hill (see above) is a small exposure of a remarkable conglomerate in a micaceous matrix of hard, dense, and very tough character. The included pebbles and small boulders consist of older quartzite and hard schist. One of the boulders measured 1'8" by 8"—9" in its largest and shortest diameter, respectively. The included masses showed signs of having undergone great pressure. This is easy to understand, the great Kondaji hæmatite bed having been upturned till all but vertical. No signs of the conglomerate could be traced along the eastern base of Tiligi hill.

Kondaji hill conglomerate.

Kaddaté schist band.

To the west of Nilgunda, 11 miles to the north, a great thickness of grey and green schists overlies the hæmatite beds which are lost to sight further west under a barren plain being covered by an immense amount of débris of blueish quartz.

At Kaddaté on the Tungabhadra, dark brown and green schists jut out into the bed of the river and cross it with a dip of 60° to 65° N. W.

The sections in the bed and banks of the Tungabhadra are most disappointing: they are few and very far between, and of no assistance

in working out the sequence of formations. The Karrabagaddi section is the best, but is only about a quarter of a mile long, and shows nothing but the two lower hæmatite beds of the Karrabagaddi set and some overlying thick beds of green, brown and drab clay schist. The two hæmatite beds, in descending from the end of the ridge where it abuts on the river, stand out like two buttresses, along which are perched some small bastions, and a short cross wall at the top. The place is picturesque, but could not have been of any military strength since the use of gunpowder, as it is completely open to attacks by artillery across the narrow river.

Karrabagaddi section.

The hæmatites, forming the crest of the ridge further to the north-east, are to some extent jaspideous, and so are those in the great spur north-east of Kunchur. This character is uncommon in the hæmatitic-quartzites of the Kunchur tract. In both places the bedding has undergone considerable contortion on a moderate scale.

The Karrabagaddi hæmatites hardly show through the alluvial spit lying opposite to the old fort, but they show strongly on the north side of the next reach of the river and form a small group of hills, but are lost to sight again before they can cross the Manganayakanhalli reach of the river.

The hæmatitic beds which form the low hills north and south-east of Manganayakanhalli appear to represent the northernmost and uppermost of the great beds belonging to the Karrabagaddi set.

Overlying these last hæmatites are an extensive series of brown and greenish-brown argillites, which in places are quite soft and shaley-looking from weather action. One of the few places in which they are exposed in fairly unweathered condition is in the bed of the Kallaspur (Cullaspoor) nullah, a few yards from the uppermost hæmatite exposed in the hilly ridge, which here forms the continuation of the Karrabagaddi band. The clay schist, which is inclined at a high angle to the west, is of a very pleasing greenish-grey colour.

Schists around Hollāl.

To the west of Hollāl are drab (pale brown) argillites, which show

in the bed of the Tungabhadra in low reefy outcrops with a west-south-west strike.

The greenish-yellow and drab schists (argillites) which form the north-west corner of the Kunchur band are only seen in rain-gullies, the general surface of the country being covered by high level gravels belonging to the old alluvium of the Tungabhadra, and these gravels again in many places by cotton soil spreads. At Hira Bannimatti on the Tungabhadra, 5 miles N. by W. of Hollāl, these argillites are seen in gullies opening into the river and there show a dip to the south at a high angle.

One of the special features of the Kunchur band is the nearly complete absence of any contemporaneous traps. The only example of the kind in the southern part of the Kunchur band occurs at the eastern base of Teligi hill. In the northern part a large show of black trappoid occurs along the northern boundary, a little to east of Kotahal (Cotahall) pagoda[1] and with it is a small quantity of crystalline limestone which is of rare occurrence in most parts of the Dharwar system. The extent of the trappoid cannot be traced, as the Dharwar boundary is completely masked by a continuous thick cotton soil spread which extends close up to Birrabbi (Beeraby), where drab and grey schists begin to appear.

Contemporaneous traps.

The boundary in this part is probably a faulted one, the chief indication of this being the abrupt way in which the great hæmatite beds of the Karrabagaddi set terminate at the northern end of Birrabi hill about a mile south-east of the village.

The basement bed of the series at Kotahal on the Tungabhadra is a poorly ferruginous but well-bedded hæmatite quartzite. At the Kotahal pagoda this hæmatite has undergone a great change, lost much of its iron, and looks as if it had been exposed to the corroding action of thermal waters at a high temperature. Some parts

[1] Kotahal village lies on the high bank of the Tungabhadra quite a mile from the temple. The village shown in the map at the western end of the name "Cotahall" is locally known as Makrabbi.

have quite a cindery appearance. The trappoid above referred to then seems to take the place of the hæmatite quartzite, and no connection between the latter and the hæmatites of Birrabbi hill is traceable.

The basement formation of the series at the east side of Birrabbi hill is grey schist (argillite). Here, as in so many places in this and other bands of Dharwar rocks, the hills increase in height and importance in proportion to the greater development of the hæmatite rocks in them.

Two or three very small and unimportant beds of crystalline lime-stone are to be found among the schists a little way up the slope of the hill south of Birrabbi hill.

Succession of formations in the Kunchur tract.

The succession of formations in this Kunchur tract, though apparently very simple and obvious, is really far from being clear. If the apparent sequence from the argillites of the Hollāl plain south-eastward to the thin platey quartzite at foot of the Hallagilwadi hills were true, it would represent a series between 70,000 and 80,000 feet thick, which is absolutely improbable. There has evidently been a great reduplication of the different members of the series, and this has probably been brought about by three great faults or systems of faults by which the hæmatites are made to appear as four series instead of one or two at the utmost. In the accompanying diagram (Plate I) I have attempted to explain what appears to me a probable solution of this puzzling section, In the absence of organic remains in these rocks it is impossible to establish geological horizons on merely petrographic data, where distinct and unmistakeable stratigraphical evidence fails.

Trap dykes.

Intrusive traps in the Kunchur band are few in number, and none present any peculiarity of interest on microscopic examination.

The large dyke which crosses the hilly hæmatite beds about 5 miles south-east of Hollāl in its northern part includes many gneissoid fragments enveloped in the mass.

Another great outcrop of trap which shows very conspicuously on the open down 4 miles north-east of Hollāl presents on the surface more the appearance of the outcrop of a flow than of a dyke, and I should certainly look upon it as the former, but for the remarkable straightness of its course for the 6 miles along which it shows a well-marked belt of very large and intensely black blocks.

Quartz veins.

Quartz veins of fair size and blue colour, of good-looking quality in gold prospector's parlance, occur in fair number near the base of the Dharwars to the south of Kalhalli gudda, on and at the north-eastern end of the hills north of Hallagilvad; also to the east and north-east of Teligi hill, and are indicated on the map. They look to be worth close prospecting despite that gold is not known to occur in this quarter.

2. *The Mallaṭan gudda band.*—This, as before explained, is the section of the great *Dambal-Chiknayakanhalli band* which lies within the limits of Bellary district. It enters the district at the gorge of the Tungabhadra at Honnur, and runs south-east for some 35 miles when it crosses into Mysore. The sequence of rocks seen in the gorge is the following, and it occupies a length of a little less than 5 miles:—

The Tungabhadra gorge section.

10. Hornblendic schists.
9. Do. trappoid.
8. Contemporaneous trap.
7. Trappoid.
6. Flaggy hæmatitic quartzite.
5. Boulder conglomerate.
4. Contemporaneous trap.
3. Schists and argillites.
2. Hæmatite schists.
1. Hornblendic trappoid.

The uppermost beds—the hornblendic schists (No. 10)—are faulted against the gneissics: the whole band in fact is thrown down to the eastward by a succession of faults which form its eastern boundary nearly everywhere, while the western boundary appears to be everywhere a simple erosion boundary.

The eastern boundary faulted.

The succession of formations on both sides of the gorge is discordant, and there appears to be an important fault on the north side of the river, which cuts off the great series of hæmatites which form the high ridge which runs north-north-west from the river to join the Dambal hills. No hæmatite series corresponding to the northern ridge is to be seen south of the Tungabhadra. The missing hæmatites were in all probability upraised by the great dislocation which took place at the time of the great crumpling up of the Dharwar system and entirely denuded away; the equivalent beds north of the dislocation now remaining having been saved from erosion because depressed below the general surface as it then was.

Fault on north side of the gorge.

The great twin hæmatite beds which cross the river at Timlapur—No. 6 of the section given above—may be seen forming the crest of a considerable ridge, which sinks down to the general level a little to the north west of Nagti Bassapur, 9 miles to the south-east. About a mile to south-east of that village, the hæmatite beds show above the general surface again and rise rapidly into the great western shoulder terrace of Mallapan gudda, and continue for 6 miles more to form the conspicuous western scarp of the high Mallapan gudda ridge. They then sink down again and are lost in the Kannavihalli (Cunnavyhully) pass. They reappear, doubtless, in the Jājkal gudda (Jaujcull Goota), but the beds here cannot be exactly correlated with those north-west of the pass.

Mallapan gudda hæmatite quartzite series.

The Mallapan gudda ridge shows a series of five or six principal hæmatite beds which are intercalated with argillites, some ferruginous and red, and others light coloured. The surface of the conical summit of the hill is much lateritized, and under the lateritic mass is a small cave some 30 feet or more in depth. Whether it is natural or artificial I could not ascertain, as I could not go into it. It contains a shrine sacred to Bettada Mallapan, the local deity, and a pooja in his honour was going on in the cave at the time of my visit. The pujari took great umbrage at my presence on the summit, so I left the cave unexplored. The panorama from the Trigonometrical station on the top, 3,172 feet above sea

The panorama.

level, is very extensive to the north, west and south, in which directions the eye ranges far and wide into the Nizam's territory, the Dharwar District and the Mysore State. To the east the view is cut off by the Sandur hill mass at a distance of from 35 to 40 miles. To the south-east by east the high granitoid hills of the Rayadrug were identifiable some 50 to 60 miles off. To the southward the view included the south-east extension of the Dambal-Chiknayakanhalli band with Guheshwar gudda (3,286′) and the Joga Maradi (3,803′) as principal peaks. Close in front of the latter the great granitoid mass of Chitaldrug is distinguishable, but as the eye wanders westward from there no more prominent points are recognizable. The nearer view along the back of the ridge, as far as Jājkal gudda, is a very characteristic one of the Dharwar rocks, so I have reproduced a sketch of it in Plate II opposite.

Rocks over- and under-lying the Mallapan gudda hæmatites.

The Mallapan gudda hæmatites underlie a great series of hornblendic schist, followed upwards by a great trapflow (seen in the pass east of Kanevihalli village), which in its turn is overlaid by another great thickness of hornblendic schists. Returning westward, the great hæmatite series is underlaid by hornblende schists with a few thin and unimportant hæmatite beds which rest upon red hæmatitic argillites, and these upon a considerable thickness of drab and greyish argillites. The succession is nowhere clearly enough seen to admit of measurements.

Jājkal gudda ridge.

As already pointed out, the Jājkal gudda hæmatite series must be regarded as the southerly extension of the Mallapan gudda series, though the great beds cannot be correlated one by one because of the intervening gap of the Kannevihalli pass—a pass which may be safely assumed to owe its existence to the local impoverishment in iron of the several beds, which thus became softer and offered less resistance to the eroding forces which shaped the ridges.

The hæmatite series is underlaid by, and intercalated with, chloritic schists, which dip east at an angle of from 60° to 70°. Intercalated with these chloritic schists and the hæmatites are some beds of red hæmatitic argillite which are crossed in ascending the Jājkal gudda.

South of Jājkal gudda the hæmatites lose their prominence, and their place is taken by chloritic and other schists which have been eroded down to a low level which continues to beyond the Chikka Haggari river. South-east of the valley the ground rises again gradually and forms several ridges of moderate size which run south-east into the Mysore territory. The eastern side of the most easterly of these ridges lies in the Bellary district. The ridge consists of poor hæmatitic quartzite and coarse schists, which are overlaid (?) by a great trap flow. This trap apparently corresponds with the great flow which lies along the eastern base of the Jājkal gudda mass and extends north-west across the Kannevihalli pass and along the eastern base of the Mallapan gudda ridge. This flow is lost sight of at, and to the south of, Chiggateri (Chiggatair) owing to faulting which has brought up the gneissic rocks in its place, but it reappears east of the Chikka Haggari and becomes conspicuous in a low hill south-west of Nagurkonda (Naugerconda).

Beds south of the Chikka Haggari.

Trap east of Jājkal gudda.

This trap flow is to the east of the Jājkal gudda mass and further north-west, overlaid by a broad band of chloritic and hornblendic schists, which are in turn overlaid by a rather big bed of hæmatite quartzite very poor in iron. This forms the main mass of the Maithur (Mydoor) hill, which lies in the apex of the triangle formed by two faults intersecting each other at a point immediately north of Maithur village.

Maithur hill hæmatite.

Faults.

An interesting outcrop of a true pebbly conglomerate with quartzite matrix is to be seen on a low hill just south of Dagunahalli (2 miles south of Huvina Hadagalli). It is much hidden by red soil, but where exposed much broken up into small pits like diamond diggers' pits, and near the western end of the end among the pits I observed two small platforms neatly edged with lumps of stone and strongly resembling the sorting platforms used by the diamond diggers at Banaganapalli. Despite of many inquiries through the taluq officials, I could

Dagunahalli conglomerate bed.

gain no information about this possible old diamond working: nobody had ever heard of it. The place has, however, an unmistakeable resemblance to a diamond digging, and the pebbly conglomerate is quite sufficiently like to the Banaganapalli conglomerate to render it quite probable that the pits and platforms are genuine traces of the work of a diamond prospecting party in former but not very remote times.

Limestones.

Limestones are of very uncommon occurrence in the Dharwars of the Mallapan gudda band. They were noted only in three places, and in small quantity, and all about the same horizon near the base of the system. The localities are: (1). On the top of the rising ground which is crossed by the high road from Huvina Hadagalli to Magalam, about half a mile from the western edge of the Dharwar area. A few thin beds of grey crystalline limestone are to be seen here cropping up over the surface of the softer schists.

(2). At the southern extremity of the hilly ridge north of Haggarnur (Huggarnoor) and about 2½ miles south of the beds just named. The limestones here are very singular in character, for they include an immense number of minute quartz pebbles which give them the nature and look of a very coarse grit with grey crystalline calcareous matrix. Overlying this grit are coarse chloritic flagstones with foliæ of crystalline greyish limestone. All dip east, and may be traced for some distance northward along the low ridge of poor hæmatitic quartzite, which runs thence more or less continuously northward to the bank of the Tungabhadra. Despite its coarseness, the gritty limestone has been quarried to some extent.

(3). The third locality where limestone was found is at the base of the Dharwars, 3 miles E. 5° N. of Harapanahalli. Here on the rise east of Hombalgutta village, crystalline limestone occurs in a dark-green argillo-silicious schist, which locally forms the base of the Dharwars. A band of this schist forms a conspicuous outcrop on the outer ridge, and at the southern end of this is a bed of the limestone which is tolerably pure and nearly two feet thick.

Close by is a poor band of hæmatite quartzite showing much contortion. A similar band occurs 3¼ miles further south-east, and forms a low rocky ridge close to the village of Mutigi (Mootyghee). The rock, which is grey and white, or purplish and white, or buff in colour, is extraordinarily crumpled on a small scale, so much so as to make a determination of its thickness a very doubtful matter. It is frequently jaspideous in texture, as is often the case in the beds poor in iron.

Mutigi hæmatite-quartzite.

Quartz reefs—Are pretty numerous in the southern and south-eastern flanks of the Jājkal mass, and occur both in the chloritic schists and the trap flow to the east of them. These reefs are doubtless the source of the gold which is washed in the streams draining this tract. A description of the gold washing, as here practised, will be found in the chapter on economic geology. The reefs, though short, are of good-looking blue quartz and deserve deep prospecting. This is the only part of Bellary district in which gold has been actually found at present.

Quartz reefs.

The streams which are washed for gold are: (1) the upper part of the Chiggateri nullah, at a place called Chengulu; (2) a small stream north-west by west of Chiggateri village; (3) a st ream known as the Bevihalli nullah, really the head-waters of the Maithur nullah; and (4) the stream which flows on the north-east slope of Jājkal gudda, and is known as the Konganahosur[1] nullah. Of these the last is much the richest and the first the second best. Bevihalli nullah is exceedingly poor in gold.

Gold washing in Konganahosur nullah.

Much of the valley traversed by the Konganahosur nullah is masked by a local laterite, really a cemented talus of the hæmatite débris washed down from Jājkal gudda. The gold obtained from the nullah from a point about a mile above the village is coarse and has been but little rolled, so has been derived probably from some reef lying in the valley.

[1] Konganahosur is not shown in sheet 59. It lies on the bank of the nullah about 2½ miles north-north-east of Jājkal gudda peak.

Uchingi Drug side band.—This branch is the northern extension of the western branch of the great Dambal-Chiknayakanhalli band, which in my paper on the Chief Auriferous Rock Series in South India, (Rec. Geological Survey of India, Vol. XXI, Part I, page 53), I described as the "Halekal gudda side band." No place of any importance stands on its surface within British territory, so I name it after the only place of any note that lies near it. It runs close to the eastern base of Uchingi Drug hill, and extends from the Mysore boundary north by west for 8½ miles, and is then lost to sight under surface *débris*.

The western boundary of this band is an ordinary erosion boundary, the eastern, which is everywhere concealed under surface deposits, is a fault boundary, the Dharwar rocks being let down several hundred feet and abutting against banded granitoids.

Potstone east of Uchingi Drug.

Between the coarse granitoid of the Uchingi Drug hill and the undoubted Dharwars is a band of coarse potstone which is of doubtful age. It is identical in appearance with other beds of potstone further to the north and north-west, which certainly seem to be part and parcel of the gneissic system (see page 32). Unfortunately its relation to the Dharwar beds to the east of it is quite obscure, and will have to remain so till some section can be found or formed which shall solve the question. The southern part of the steatite ridge looks as if it had no connection with the Dharwars. The rock contains many crystals of greenish white talc.

Chettanhalli schists and quartzites.

Lying eastward of the potstone are greenish brown schists which are seen to the east of Chettanhalli village[1], 2 miles south-east of Uchingi village. These schists, which are several hundred feet thick, are overlaid by a considerable thickness of pebbly, gritty and waxy quartzites, these latter being generally of a pale sea-green colour. The included pebbles are generally of pale colour, and many of them are a good deal deformed by shearing acting. These pebbly beds form the upper third of Chet-

[1] Chettanhalli village lies really quite half a mile east of the position given to it in sheet 59.

tanhalli hill (2,440') which rises some 400 feet above the surrounding country. The hill being very bare of vegetation, the disposition of the quartzites is very distinct, and they are seen to dip from 25° to 30° east. They are overlaid by schists and rather flaggy argillites, which, as above mentioned, are faulted against the gneiss to the eastward.

In the northern part of the band the quartzite conglomerates do not appear. They seem to die out in the hill east of Uchingi Drug. At Giddanapalli (Giddanaganpully) green brown schists of the same character as those at Chettanhalli, and similar schist with traces of a black trappoid, are to be seen also between Nitchapur and Degga Bassapur.

Great Trap dyke.

One very large trap dyke in the centre of the side band cuts across the south flank of the hill east of Uchingi village, and continues north-west for some 4 or 5 miles, forming a conspicuous feature in the landscape.

Quartz reefs.

Several good-looking and promising reefs of bluish quartz run northward through the pebbly quartzites north of the Chettanhalli tank. They are worth prospecting as the central part of the side band at Halékal gudda, in Mysore, was found to be very fairly auriferous.

3.—The Sandur hills and Copper mountain band.

This area is so strangely irregular in shape that it can hardly be described as a band, but rather as a couple of bands bracketed together near their respective centres. Both stand out high above the surrounding country, but sink down low at their extremities, more especially at their northern ends. The two minor bands thus coupled may be regarded as two great synclinal folds running from north-west to south-east.

The western of these two great synclinals forms the *Sandur hills* (A), a group of remarkable flat-topped masses occupying in plan a leaf-shaped area 32 miles long and 11 broad in the centre, and tapering

acutely towards either end.[1] East of the Sandur hills lies an irregular tract of Dharwar rocks which I will call the *Joga-Sultanpur* area (B), partly hilly and partly level, which forms the connection—the bracket, as it were—which unites the Sandur synclinal with the Copper mountain. The eastern synclinal is the long narrow rocky ridge, the highest part of which is called by Europeans the Copper mountain (C), because prospected for copper in the days of Tippoo Sultan. It measures 32 miles in length by from 2 to 4½ in width.

The Sandur synclinal.

(A).—*The Sandur hills* enclose a long narrow valley which is simple in its northern part, but to the south divided into two lesser valleys by a high but narrow spur—the Devadara ridge—which seemingly belongs to the western side of the synclinal fold. The structure of the synclinal fold itself is by no means simple. It is much confused by the extraordinary thinning out of most of the rocks composing it, by sundry faults, and by great inversions on the eastern side of the fold. When seen from the south-west or north-east the Sandur hills present a remarkably flat-topped appearance, and it is difficult to imagine that they really surround a median valley. Where the synclinal attains its greatest width it is cut across by the valley excavated by the Narihalla, a small river rising some distance to the south-west of the synclinal. The direction of the cutting thus made is from south-west to north-east, and the river in eroding its way through the great barrier has cut two very fine gorges which afford easy approaches to the Sandur valley and give excellent sections of the great side ridges. The western of these gorges is known as the Obla, or Ubala Gandi; the eastern as the Bhima Gandi. A third pass at the northern end of the synclinal also allows of easy access to the valley, but fails to give any useful section of the rocks in that part.

The Narihalla and its two gorges.

[1] The extreme north-west end of the Sandur synclinal lies on the left bank of the Tungabhadra in Sir Salar Jung's jaghir of Koppal Drug in the Nizam's State, where it forms a narrow ridge, the continuation of the dark trappoid, which crosses the river and extends 4 or 5 miles north-west from the river.

The mass of the Sandur hills is arranged in four divisions, two of which lie north-west of the Narihalla river and two to the south-east. For convenience, I must give separate names to the four parts, which the natives have omitted to do, though many isolated spurs and ridges have separate names. The division north-west of Sandur had best be called the Raman Drug division, "a", from the curious old hill fort which crowns the central part of the ridge and close to which lies the modern military sanitarium of that name. The north-eastern division may be called the Ramgol division, "b", from a very beautiful ravine of that name which lies about the centre of the ridge. A much lower parallel ridge lies outside the Ramgol ridge, but merges into the main ridge at its northern end.

Sub-division of the Sandur hills.

The Raman Drug division "a".

The Ramgol division "b".

The south-eastern division lies south of the Narihalla, and is separated by the Mudkalpenta valley from the Devadara spur and by the southern extension of the valley from the south-western division. The former may conveniently be called the Donimalé division, "c", and the latter the Kumáraswami plateau, "d", (or division). The Devadara ridge is a northerly offshoot of the latter plateau and should be reckoned to belong to it, as it is part of the western side of the great synclinal.

The Donimalé division "c".

The Kumáraswami division, "d".

The Kumáraswami plateau is so called after the famous temple of that name which stands near the western end of the plateau.

The Donimalé has a lofty and conspicuous spur to the east, which is called the Vala Bhadra Konda, and which unites with the Donimalé plateau some 5 miles to the south.

The Sandur hills are very imperfectly represented in the sheets of the Indian Atlas (Nos. 58 and 59),—a fact which made the working out of the geological structure a far more difficult and laborious task than had good maps existed. Even the one-inch map of Sandur State of the Madras Survey, which I only obtained a considerable time after commencing upon the

Insufficiency of topographical maps.

State, though an immense help, was lacking in definition in some parts; for example, to the south-east of Kumaraswami's temple, where several large and deep ravines draining to the south-east are absolutely omitted. They are omitted also from the atlas sheet No. 59. The only trigonometrical point in this quarter—that marked in the atlas sheet as "Malla Ammanhurroo"—is unluckily not given in the one-inch map, and the survey as shown in the one-inch map stops abruptly along the fiscal boundary of Sandur State, so it was impossible, in the absence of any one fixed point, to effect any corrections or additions to the one-inch map. In sheet 59 a second point was wanted on which to make observations, to settle the positions of the great ravines above referred to.

The remarkable flatness of the Sandur hills has already been adverted to, and it was one of the principal difficulties to contend with in mastering the structure of the hill masses, for there are no high points from which to get commanding views enabling one to take in the obscure relations of the different formations, and there are no conspicuous points of which to make landmarks.

Correlation of formations on both sides of the synclinal.

It is not yet possible to correlate exactly all the beds on both sides of the synclinal, the continuity of the several hæmatitic beds being too uncertain to let one feel positive that the mere numerical sequence is enough for such identification. At both ends of the synclinal several of the beds thin out and die away completely, while at the northern end a good deal of faulting renders all conclusions uncertain and hazardous. Still it is, I believe, safe to regard the Hoshalli trap flow in the south-eastern valley between the Donimalé and the Devadara spur of the Kumaraswami division as the central and uppermost bed of the synclinal.

Predominance of ferruginous rocks.

The Sandur hill and Copper mountain series is by far the fullest and most varied of any of the Dharwar bands or areas as yet worked out. The most striking feature established is the predominance of the hæmatitic iron beds, and more especially of the hæmatitic quartzites in which the silicious laminæ

alternate with laminæ of hæmatite, varying from a soft, rather argillaceous, red ore through micaceous ore to massive glittering specular iron. In richness of iron the beds vary from very poor, nearly pure quartzites, to very rich, in which latter case the ferruginous laminæ outnumber the siliceous ones eight or ten times. None of the ores have, so far as I know, been as yet analysed, so their percentage of phosphorus is as yet undetermined, and it therefore remains to be seen whether, if smelted on a large scale by Thomas and Gilchrist's Basic process, they would yield a slag so rich in phosphorus as to be a valuable artificial manure, and thus to command a good market by which the mere by-product would go far to pay the prime cost of the smelting.

The Nariballa section.

No section gives so good a sequence of the several formations making up the Sandur hill series as the section along the Narihalla from the western boundary near the village of Somulapur to a little beyond the village of Ettinahatti, which is quoted below:—

	18. Hosballi contemporaneous trap.			
	W. 17. Schist.	Hæmatite quartzite schist.	17.	E.
Devadara hill beds.	„ 16. Hæmatite quartzite and schist.	Hæmatite quartzite.	16.	„ Bhim Tirth bed.
	„ 15. Schist.	Schist.	15.	„
Sandur flow.	14. Trap, contemp.	Hæmatite quartzite.	14.	„ The gorge bed.
	„ 13. Clay schist.	Schist with contemp. trap.	13.	„
	„ 12. Trap, contemp.	Hæmatite quartzite.	12.	„
	„ 11. Hæmatite quartzite.	Schist.	11.	„
	„ 10. Trap, contemp.	Hæmatite quartzite.	10.	„
The gorge beds.	9. Hæmatite quartzite.	Schist.	9.	
	8. Ferreous argillites, red, brown, and chocolate.	Hæmatite quartzite.	8.	
	7. Hæmatite rock.	Schist with contemp. trap.	7.	
	6. Schist.	Hæmatite quartzite.	6.	Long cliff bed.

5. Hæmatite quartzite.	Schist with contemp. trap.	5.	
4. Schist, green.	Hæmatite quartzite.	4.	Brecciated bed.
3. Hæmatite quartzite.	Schist.	3,	
2. Schist, gritty brownish-green, very thick.	Hæmatite quartzite.	2.	Ettinahatti bed.
1. Schist, dark-green, hornblendic.	Trap, contemp.	1.	

The accompanying diagrammatic section (Plate III) shows the relations of the beds forming it, as they appear to me after much careful study. Of the inversion of the eastern side of the synclinal there cannot be the least doubt. It only affects the beds in the central part of the ellipsoid, and both to the north and south of the line of section they re-acquire a normal position. The position of this section is of the greatest possible assistance in studying the structure of the four divisions of the Sandur ellipsoid, for it allows of an approximately exact correlation of the members of the series in a north-westerly and south-easterly direction. In the descriptions of the sections worked out in other parts of the ellipsoid, some at least of the beds can now be referred to this type section with a degree of certainty which can rarely be attained in dealing with a great series of much disturbed formations which have undergone much regional metamorphism. Several of the sections in the several divisions of the Sandur hill mass are deserving of separate study and comparison amongst themselves and with the standard section just described: they will therefore be taken in the order in which the four divisions have been placed above (page 90).

A.—The Raman Drug, or North-Western Division.

This is by far the best known, generally, of the four divisions of the Sandur area from the fact that on it stands the well-known military sanitarium of the same name which is reached by three excellent ghat roads—two on the north-eastern side of the ridge from Hospet and Sandur respectively, and one on the western side leading down to Narayandeverkerra (Naraindaver Kerra). In shape it is a very

acute isosceles triangle extending from the Narihalla western gorge, the Oblagandi, to the banks of the Tungabhadra, measuring 19 miles along the main ridge, which corresponds with the perpendicular line dropped from the apex to the centre of the base, which latter measures about 7 miles across. The ridge is about half a mile across its top on the average in the south part, but narrows greatly to the north-west of Raman Drug station. The highest part of the ridge lies between the station and the base of the triangle, and may there be from 100 to 150 feet higher than the Trigonometrical station, in the station which stands 3,256 feet above sea level. The ridge rises 1,400 feet above the Sundur valley, and from 1,500 to 1,600 feet above the western plains. It is nowhere cut into very deeply by ravines, but more so in the south-western slopes than elsewhere. Here the basset edges of the outcrops make several fine cliffs overhanging to the west. The top of the ridge is generally, but poorly, wooded, the hard hæmatitic breccia which covers much of its surface being unfavourable to vegetation. The only trees which attain to fair size are figs of several species. The deeper ravines are thickly wooded with thorny trees: but little deserving the name of timber is at present produced, the forest not having as yet had time to recover from the destructive action of forest fires continued from time immemorial.

That they will recover in due time, thanks to the wise energy of the Forest Department, admits of no doubt as the weathering of the varied rocks constituting the ridge gives rise to excellent soils in great plenty. Great part of the division is included in the new forest reserve.[1]

Raman Drug, Western section.

The Raman Drug division is poorer in useful sections than are the others. The best of them is that to be seen by following the ghât road leading up the western slope. The sequence here seen is as follows:—

8. Schists.
7. Hæmatite quartzite, rather shaley in parts, chocolate to red in colour "Prospect Point" bed.

[1] The forests on the Raman Drug ridge, the Ramgol ridge, and the central part of the Donimalé division have been leased by the Government of Madras from the Rajah of Sandur, and are being conserved with marked success.

Southward of the station the ridge rises very gradually, and about 2 miles to the southward is probably from 100 to 150 feet higher. The rise is hardly perceptible as you proceed along the crest of the ridge, but is distinctly visible from plains to the west and when at some distance from the ridge.

North end of Raman Drug ridge.

The northern extremity of the Raman Drug ridge is very obscure from the great hæmatite talus covering its flanks; the hæmatite beds are inverted and dip to the west instead of the east. They appear to be cut off by a fault, for they cannot be traced across the Tungabhadra. The only Dharwars traceable in the bed of the river are massive hornblendic rocks, trappoids, which form a great barrier, giving rise to a formidable rapid at half flood. The river is quite unfordable here, and no ferry exists for several miles up or down its course.

Great talus.

The hæmatite talus, which is almost everywhere a remarkable feature along the base of the Sandur and other hills of Dharwar age, completely conceals the junction with the gneiss for a distance of fully 13 miles along the western base. Among the masses of ordinary hæmatite quartzite in the talus are vast quantities of very rich red soft argillaceous hæmatite derived from one of the lower beds. This would yield a splendid red pigment for the mere trouble of collecting and grinding.

Manganiferous nodules.

In the argillite schist beds No. 4 in the western section are numerous nodules of a manganese ore, while in an associated bed of massive quartzite the ore occurs in laminæ or in flattish concretions. They are an ore of manganese in a lower state of oxidation than dioxide, and appear to represent either Braunite or Hausmannite. Their quantitative analysis by Mr. Philip Lake, B.A., will be found in the chapter on Economic Geology.

The summit of the Raman Drug ridge is very frequently much obscured by hæmatitic *debris* which occurs in two forms: firstly, as an ordinary pseudo-laterite, either massive or encrusting, and secondly, as a breccia of angular fragments of hæmatite rock, often

very rich in iron and of a deep reddish or blackish purple colour. The enclosed fragments are of all sizes. Masses of the hæmatite rock *in situ* often protrude through the overlying breccia, and where the beds are much crumpled it is often hard to be sure whether the protrusions are parts of the breccia or part of the rock *in situ*. These protrusions are so frequent and large that the breccia cannot be shown on the map as a continuous deposit.

The elevation of the central part of the Raman Drug ridge shows for several miles hardly any variation, a few slight saddles excepted, which are due to the erosive action of the atmospheric forces having cut more deeply into locally softer formations. Such a saddle occurs to the north of the sanitarium, and is crossed by the western or Narayandevakerra ghât which unites with the northern and southern ghâts proceeding to Hospet and Sandur.

The Raman Drug ridge extends above a mile further to the north-west than does the eastern or Ramgol ridge, to be described further on.

The ridge is throughout simple, and the crest-forming beds very rarely rise into elevations of any size. The exceptions to this are not numerous, and only one is of such height and importance as to form a special feature in the landscape. This is the hæmatite No. 18 of the Raman Drug eastern section, which represents the Devadara series of the Narihalla or Sandur section. This hæmatite bed, with some associated schists, rises into a ridge of from 200 to 300 feet high above the Sandur valley to the eastward of Bevihalli. This ridge maintains this height while its course remains easterly, but sinks down rapidly into the valley, where its course trends south-east on the one hand and north-west on the other. At the southern trend the hæmatite bed, which I will call the Bevihalli bed, diminishes greatly in size and importance, and is for a time nearly lost sight of, but shows in a small hill close to Timlapur, and dies away again under the valley of the Narihalla, but re-appears, and then in great force south of the river, and rises into the important Devadara ridge, to be described further on as part of the south-western or Kumáraswami division of the Sandur hills.

The Bevihalli bed.

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The Bevihalli bed.

A hæmatite band which underlies this Bevihalli band in the high ridge, but is there very inconspicuous, increases in importance to the northward and forms a narrow craggy ridge about 100 feet high to the north-westward of Hunshahuti, a hamlet 2½ miles north by west of Raman Drug. The rock here has changed into a hard ferruginous argillite of deep brownish purple colour, with many included whitish specks of decomposing felspar. It is a remarkably handsome rock, but not tough enough to be used for building purposes.

Hunshahuti hæmatite bed.

A traverse I made over the Bevihalli ridge from the northern edge of the Sandur trapflow, starting from a little to the west of the 31st milestone on the direct high road from Ettinahatti to Raman Drug and up the high ridge east of the little tank (half a mile north of the road), gave the following section:—

Bevihalli ridge section.

18. Trap, Hoshalli flow.
17. Schist, dark green.
16. Hæmatite quartzite, very jaspery. Much brecciated in parts.
15. *a*. Trap, green and dirty.
b. Quartzo-chloritic rock, coarse.
c. Hæmatite bed, obscure.
d. Trap.
e. Trappoid.
f. Schist, purplish.
14. Trap. Sandur flow.

The various beds bracketted together under No. 15 represent the lower schists of the Devadara ridge group, and would probably all be correlateable with the beds in the ridge south of the Narihalla if the latter could be cleared of the heavy talus which has fallen from the cresting hæmatite bed No. 16.

B.—The Rámgol, or North-Eastern Division.

Unlike the Raman Drug division, the Rámgol division does not contain only a solitary ridge of great size and importance, for, in addition to the high main ridge, there are two considerable ridges running parallel with it on the eastern side and forming features of importance. Owing to the action of the torrents draining these outer

ridges they have both been eroded to great depth and furnish sections of exceptional interest, which are described further on.

Hospet hill.

The northernmost extremity of the ridge forms the bare conical Jonnel Rashi hill close to Hospet, which is cut off on the western side by the Rámanagundi pass from the Râman Drug ridge. To the north of the ridge the beds are cut off short by a great fault indicated by the great run of brecciated quartz which runs along the boundary by some four miles. Four well-marked hæmatite beds cross the little ghât by which the Sandur road enters the synclinal valley. Three of these beds run up into the Jonnel Rashi, trend northward on its summit, and are lost on its northern base, being doubtless cut off by the fault above mentioned. At the western end of the summit the beds dip from 70° to 75° west. Jonnel Rashi is far higher than the extreme north end of the Raman Drug ridge. Eastward of Rampur ghât[1] the main ridge rises very rapidly and steeply till it is crowned by Jambanath Konda, a very bold and conspicuous peak 2,980 feet high. South-eastward of this the ridge widens gradually and rises simultaneously, so that where the north-east ridge looks across to Raman Drug in a southerly direction the two ridges appear to be equally high.

Jambanath Konda.

Papinayakanhalli section.

The stratigraphical sequence in the Rāmgol ridge is best illustrated in the long ravines cut by the streams starting from the main ridge and flowing northward. The most westerly section, and the most complete, taking it all in all, is that met with in the ravine south of Papinayakanhalli. The sequence here seen is the following :—

15. Hæmatite rock, very jaspideous, much crumpled and breceiated.
14. Trap ?—a greatly decomposed earthy rock of purple colour.
13. Hæmatite rock, very thick, brecciated, with small quartz veins.
12. Trap ?—an earthy green and purple rock.
11. Schists, argillites—chocolate, and sometimes lavender coloured.
10. Schists, green, chloritic ?—of great thickness.
9. Hæmatite quartzite, a thin poor bed.

[1] Rampur ghat is a low saddle on the south-eastern side of the Jonnel Rashi, and is crossed by the high road leading from Hospet to Raman Drug and Sandur.

8. Schists, green.
7. Trappoid rock, black.
6. Schists, dark, nearly vertical.
5. Slates, greenish, badly cleaved.
4. Schists, green, silky texture.
3. Schists, green, coarse.
2. Hæmatite rock, poor.
   Gap.
1. Schist, dark.
   Talus.

Bed 15 forms the western scarp of the ridge overhanging the central valley opposite to Hunshahuti.

The next important section occurs rather more than four miles to the south-east in the most easterly of the three ravines lying south of the village of Joga.[1] The rocks show up well nearly everywhere along this section, and the gaps caused by superficial deposits are so small that they may be safely ignored. The section extends in descending order from the foot of the main northward to Joga valley, a distance of about 2½ miles, and practically follows the line of the path, which is very fairly straight.

The Joga section.

The following is the sequence of formations exposed:—

Joga low-level section.

25. Trappoid.
24. Schist, dark-chocolate, reddish, or banded.
23. „ „ argillaceous.
22. Trap, a thick contemporaneous flow.
21. Schist.
20. Conglomerate, thin.
19. Schist, argillaceous.
18. Conglomerate, thin.
17. Schist, argillaceous.
16. Conglomerate—Schisty micaceous matrix, thick; enclosed pebbles altered by pressure.
15. Schists argillite?
14. Hæmatitic (thin).
13. Schists.
12. Hæmatitic (very thin).
11. Schists.
10. Trap (thin).
9. Schists.
8. Hæmatitic (thin).

[1] The map (sheet 58) shows only two out of the three torrents which unite at Joga: the central one has been left out, and the course of the western one is incorrectly given.

7. Schists.
6. Hæmatitic (thin).
5. Schists, hornblendic.
4. Trappoid (schisty).
3. Schist, hornblendic.
2. Schist (much kunkarised).
1. Trap "Joga" flow.
Granite.

In this part of the north-east range the mineral character of the different formations often varies very rapidly, rendering a correlation of them with the formations exposed in the other sections, even at no great distance, very difficult, or quite impracticable, unless it is possible actually to follow up the outcrops, a measure requiring great expenditure of time and labour. The most constant beds in this region are the hæmatite ones, especially when hard and jaspideous or quartzitic; these generally form strong outcrops, rising well above the softer bed under and overlying them.

Changes of mineral character of formations.

The Joga section affords a striking example of a great change in mineral character of several of the great hæmatitic beds which form such conspicuous features at the eastern side of the Bhimagandi, or eastern gorge of the Narihalla. Close to Ettinahatti these hæmatite beds are of great thickness and rich in iron. Four miles to the north-west they have lost nearly all their iron and are represented by a great thickness of grey banded jaspery hornstone containing little or no hæmatite. One small dirty-looking bed of very poor hæmatite quartzite underlies the hornstone as seen at the western end of the high ridge. A few hundred yards further west it has dwindled still more and has a thickness of only two or three feet and cannot be traced across the Joga stream bed. The hornstone beds have also become altered, and disappear so suddenly as to suggest the presence of a fault cutting them off. No other evidence, however, of the existence of a fault was found.

Joga high level section.

The conglomerate series (in which I include Nos. 18 to 23 of the Joga low level section) is much better seen by climbing the high ridge, which I will call the Ettinahatti ridge, as its southern end is close to that village. Starting

northward from the northern edge of the trapflow No. 24 of the low level section, the following series was crossed:—

17. Schists.
16. Conglomerate, with grey to greenish schisty matrix.
15. Ditto with more gritty matrix, reddish, with drab and white beds very thick.
14. { Hornstone / (quartzite?) / Breccia. } banded grey with a few red stains, brecciation on a tremendous scale, beds of great thickness.
13. Hæmatite gritty, bed, poor, dirty-looking.
12. Argillite hæmatite.
11. Hæmatite rock—banded reddish.
10. Do. gap do. white and grey—rich microcrystalline hæmatite.
9. Argillite schist red and variegated (thick)?
8. Conglomerate, drab, schisty matrix.
7. Hæmatite rock, very poor, much veined with quartz.
6. Schist.
5. Hæmatite rock, very poor, thin.
4. Schist, greenish,
3. Do. dark purple—grey.
2. Do. greenish.
1. Trappoid? Joga trapflow?

The line of section I had to follow from the nature of the ground diverged somewhat to the east near the top of the ridge, but probably not more than a quarter of a mile at the outside. North of the ridge it trended west again to within 50 yards or so of the low level section.

Breccia and conglomerate.

The true conglomeratic character of the beds overlying the great breccia No. 14 is very marked. On many planes of jointing capital sections of the included pebbles are to be seen. Some of the upper beds are very pebbly, and among these I noticed two thin ones of reddish gritty sandstone, the psammitic character being well brought out by weathering. The reddish beds show the conglomeratic structure far more distinctly than do the white or drab ones. The included pebbles consist of various schists, quartz grit and banded hornstone. Some much weathered pebbles seemed to be granitoid and gneissic, but the determination is doubtful.

The Ramgol ravine section.

The sections in the valley of the two other branches of the Joga stream are much less satisfactory, and the map is very faulty, so I am doubtful as to further exact

correlations, although there is no doubt as to the westward extension of the conglomerates and their associated beds. The middle stream of three uniting at Joga is not shown on the map: it rises on the main range and falls down a splendid gorge with red and grey cliffs rising close upon, if not over, 200 feet. The predominant rock is a superb variety of banded jaspideous hæmatite rock, of vivid red and dark-grey black or greyish brown in stripes, and often exquisitely vandyked. Nowhere else did I see such splendid specimens of richly coloured rock as in this great Ramgol ravine. A good deal of rich vegetation grows near the top of the ravine, and along the steep scarps below it, showing what the soil is capable of bearing, and would do so if allowed fair play and a truce from jungle fires and goats. The gorge makes a great sweep to the north-west and west, and at the top receives two streams which drain a rather deep upland basin, of which the map gives no indication. The path leading from Joga to Hunshahuti skirts the south side of this basin. The highest part of the main range is the hæmatite bed overlooking the Sandur valley: it represents (doubtfully) the Timmappanghar (Timanghur) jaspery finely-bedded hæmatite rock, and is of great thickness. Underlying it are, in downward succession (after crossing a rather wide gap of 200 to 300 yards, where no rock is seen), a jaspideous banded hæmatite, schists and argillites; another highly jaspideous banded hæmatite, red argillite, and trap; below this come three or more thick hæmatites with intercalated schists and trappoid, which together form the gorge rocks. They rest on dark banded slatey rock (clay-slate ?), the beds of which seem to be inverted and to hang over 1° or 2° westward. These, again, are underlaid by other dark schists and conglomerates to be mentioned presently.

Section on Ramgol stream.

A considerable thickness of conglomerates with greenish schisty-looking matrix is seen in the bed of the Ramgol torrent underlying the trapflow which forms No. 24 of the Joga low-level section. The matrix when freshly broken is a dense, silky textured, dark greenish-black chloritic mass.

The conglomerates.

It looks very soft externally, but is in reality very hard and desperately tough. All the in-

cluded pebbles examined by fracture were quartzose: they are numerous, and show no special distortion at this place. Above the trapflow No. 24, and close to the foot of the main range, is another great thickness of conglomerates with similar dark matrix and identical general external features. Dark-green schist also occurs largely. Many of the included pebbles are of large size. Many consist of banded grey hornstone like that of the Joga high-level section: one, very large one, was found to consist of coarse gritty quartzite.

Gangadi ravine and stream.

The third of the streams uniting to form the Joga nullah descends from the main range by a very fine ravine called Gangadi, which nearly equals the Ramgol in grandeur. It does not cut so deeply into the mountain side and is full of dense vegetation, bamboo predominating. During the rains there must be a pretty waterfall, some 20 feet in height, at foot of the range, while a few yards below it a large but shallow pothole forms an exquisite miniature tarn, full of limpid water, with water-lilies and ferns. The valley opening from the top of the Gangadi ravine is too thickly overgrown with low forest to show the rocks it has been excavated in.

I am not able to correlate the Papanaykanhalli section closely with the Joga section, having had no opportunity of re-examining the intermediate tract as exhaustively as I could have wished to do. The thick green schists are in all probability the extension of the hard chloritic conglomerates of the Ramgol stream valley. The number of hæmatitic beds has decreased very considerably, probably by thinning out altogether.

The "Water slide" section.

There is a very interesting section of conglomerates, where the stream which drains the deep valley on the eastern side of Jambonath Konda breaks through the outer ridge. The section here seen is as follows:—

7. Trappoid, green.
6. Schist, green.
   Gap.
5. Conglomerates with siliceous matrix.
4. Schists.
3. Conglomerates and grits, green schisty matrix.
2. Hornblendic rock, slaty?
1. Schists, dark micaceous argillites.

The conglomerates are in all probability representative of the Ramgol and Joga stream conglomerates. A singular and interesting travertine formation resting on the dark micaceous argillite (No. 1) at foot of the gorge will be found described further on. The "Water slide" would be a good name for the place in the absence of any known one. The low ridge of conglomerates which the stream breaks through just above the "Water slide" rises rapidly to the westward and forms the main easterly spur of the Jambonath Konda.

The angle of dip of the conglomerates at the gorge is very high, but they show no sign of deformation; but as the ridge is followed the dip increases somewhat, and the numerous pebbles included in the conglomerate become greatly squeezed and elongated in the direction of the strike of the beds. This distortion is found to increase till abreast Jambonath Konda Trigonometrical station. Here the matrix of the rock is a silky (micaceous) striated quartzite sandstone with numerous siliceous inclusions resembling anything but the rounded pebbles they originally were. They have been squeezed into long flattened cigar-like bodies! But that I traced them, foot by foot, along the outcrop of the conglomerate bed, I should unhesitatingly refuse to believe the alteration they have undergone. However, the evidence is quite irresistible. The conglomerate band continues westward of Jambonath Konda, but thins out rapidly. It can still be traced at the gully which lies west of Jambonath temple gully, and has here a thickness of only 25 feet. Further west it thins out more and more, and disappears before one reaches the little Rampur ghât which is crossed by the Hospet-Sandur road.

Deformation of pebbles in the conglomerate.

The conglomerates which figure so largely in the Joga and Ramgol sections are not seen 4 miles south-eastward in the Bhimagandi gorge. The character of the rocks seems to have changed completely, and there is no trace of brecciation in the Ettinahatti hæmatite beds, which are very fairly rich in iron, and can only be described as very ordinary hæmatite quartzite. These beds abut on the Bhimagandi gorge by which the Narihalla

The Bhimagandi gorge.

flows out of the Sandur valley. The scenery in the gorge is very fine, and so also are the views of it both from the east and west.

One of the most conspicuous objects in the Bhimagandi gorge is a great detached rock which rises in the middle of the valley on the north (left) bank of the Narihalla. The river evidently in former ages flowed round its northern side as well, and isolated it entirely from the great hæmatite quartzite bed, which towers up conspicuously about the middle of the gorge. The detached rock forms a double gate in the pass, the river flowing through the southern one, and the high road passing through the northern one. Newbold, in his article on Sandur State, describes it in some detail. It shows conspicuously in the accompanying sketch (Plate IV) of the Bhimagandi gorge, taken from the foot of the hill 2½ miles east of the mouth of the pass. The Oblagandi gorge, by which Narihalla enters the Sandur valley, is hidden by the gate rock, which also hides the north side of the second gate made by the Nandgarh ridge.

Nandgarh ridge.

The finest object, however, is the Nandgarh ridge, which forms the second or western portal in the Bhimagandi gorge. It is slightly inverted, having a very high easterly dip. It towers up over the Narihalla river in the most commanding way, and the small fort which crowns it must have been perfectly impregnable in olden times, except by blockading and starving out the garrison. It consists of a moderately ferruginous and decidedly jaspery hæmatite quartzite. Its southern extension into the Donimalé plateau forms a very important bed, which shows conspicuously on the south side of the gorge, and which will have to be referred to when dealing with the south-eastern division.

Bhimtirth ravine.

To the north-west of this Nandgarh bed is a deep recess in the ridge known as the Bhimtirth. It is surrounded by fine hæmatite quartzite scarps and, being full of trees, is a very pretty spot. It owes its existence to the eroding action continued through long ages of the small watercourse which comes down from the saddle between the Nandgarh bed and the Bhimtirth bed. The recess is really a wide ravine with very cliffy scarps in its upper half.

Timappangarh Drug.

Rather more than two miles north-west of the Nandgarh gate in the Bhimagandi gorge, the great hæmatite beds which there have a north-west to south-east strike make a very marked and conspicuous bend to the west, and the apex of the outcrop on the south side of the curve is crowned by a small ruined hill fort known as Timappangarh (Timangur). The fort stands on a great bluff, squarish in outline, which juts out from the general scarp of the Ramgol ridge. The rock is beautifully banded and highly jaspideous in texture, and shows in parts a beautifully vandyked contortion on a small scale. The colours of the rock are also very good, the laminæ of quartzite being white, rich cream, pink in many shades, and red, up almost to a pure vermilion tint, while the hæmatite laminæ vary from reddish grey up to pure steel grey, sparkling with minute crystalline facets of specular iron. The exposed side surfaces of the hæmatitic laminæ frequently weather of a rich purple. The weather-resisting power of the hæmatite quartzite is very well seen on the bassett edge of the Timappangarh ridge in the hardness of the outcrop and its commonly glossy jaspideous surface, which is rarely covered by lichens except in very exposed and greatly weather-beaten crags or ledges.

The amphitheatre formed by the curve of the strata below the Drug scarp is thickly covered by fallen masses, of all sizes, of the Drug hæmatite bed, which lie in such thousands all over the surface that the trapflow, which should really show there, is completely hidden. The number of exquisite specimens of jaspideous rock here seen is so great that it is difficult not to wander for hours among them. The beauty of the jasper rock and its fitness for art uses will be referred to again in the chapter on Economic Geology.

Inversion of beds on Hunshahuti hill.

The most prominent object in the central part of the North Sandur valley is the great hill jutting out south-westward from the Ramgol ridge 7½ miles north-west by north of Sandur town and which may be conveniently called the Hunshahuti spur. The structure of it is not very easy to understand, for the broadening out into a little plateau of the

hæmatite bed which forms the summit seems to be due to a very strong but purely local inversion, quite distinct from the much more important inversion seen in the Bhimagandi gorge.

The eastern side of the hill is a sloping plateau of hæmatite quartzite, which is a broadened outcrop of a large bed of that rock, that is, in all probability the continuation of the great bed that underlies the Timmapangarh Drug just described. The surface thus forming the eastern slope of the hill is really the under-surface of the great hæmatite bed that has been overturned by the local inversion above referred to. If I am right in my interpretation of the courses of the great hæmatite beds seen at Timappangarh, which are by no means distinct in the western limit of the great curve they there make, this Hunshahuti summit-bed represents the great bed out of which the Bhimtirth recess has been excavated. The bed, as seen on the summit of Hunshahuti hill, is also much contorted on a small scale, too much so to make its east ward-dip measurable with any accuracy, but it is probably about 40° or rather less, which shows that the inversion was there a very strongly marked one, amounting almost to a thrust plane.

This slope is the largest superficial exposure of the hæmatite quartzite that does not occur in an inaccessible scarp or actual cliff. It is both over and under-laid by contemporaneous trapflows. It is not easy to understand why there should be so great an inversion here, for the overlying beds and lateral extensions of the same bed do not show such complete overturning.

C.—The Donimalé or South-Eastern Division.

This is the smallest of the four divisions of the Sandur synclinal, but not the least interesting, and it contains a great deal of beautiful scenery in its northern, central and eastern parts, as well as several very puzzling sections, of which I can at present only offer tentative solutions. It is named after the plateau forming its north-western extremity. The Donimalé proper is in plan wedge-shaped, the base of the wedge abutting on the Bhimagandi gorge, and the apex lying

some five miles to the south-east by south. The base of the wedge measures about 3 miles across.

The inversion of the upper beds of the eastern side of the synclinal, though less conspicuous than to the north of the Bhimagandi gorge, can be seen for some distance south of the Narihalla valley on the west flank of the Donimalé, and again in the hills to the south-south-east of the apex.

Thinning out of the formations generally.

To the south of the apex the strata composing the east side of the synclinal very generally commence to thin out, and an area of progressively diminishing sedimentation is entered upon and is found to extend to the southernmost end of the synclinal, where the strata have dwindled away to mere films which lie around the rugosities of the old gneissic surface. The thinning out of the beds is very remarkable here, and can be far better realised here than at the northern extremity of the synclinal.

The general surface of the Donimalé plateau is fairly level, but a few trifling ridges rise out of it here and there, formed by the outcrops of hæmatitic beds which project slightly over the surface and are generally covered with thick scrubby jungle. The general surface is but thinly wooded, but *per contra* it is mostly densely covered with long grass, which is not at all easy to traverse, and completely conceals the ground between the low outcrops just named.[1]

[1] Everybody that has crossed spreads of dry grass in the hot weather knows how extremely slippery it makes one's boot soles. I never realised this more than when pushing my way across the trackless grass spread on the Donimalé. The growth was much too thick and high to let the ground be seen, and where uneven ground or loose stones were hidden under the grass, stumbles were incessant and sprawls not infrequent. My native companions fared almost as badly as I did despite their bare feet. Down among the long grass one got into a much hotter atmosphere so full of dust as to be perfectly suffocating and to cause violent fits of sneezing, as in hay fever. A little dog that followed me through those 5 miles of long grass suffered greatly from the hot dusty air and became quite ill from it.

The dust seemed to be purely vegetable in its nature and was doubtless formed by the breaking up of the crisp dead grasses and leaves under action of brisk winds. The presence of such dust cannot fail to give rise to an explosive and immensely more rapid spread of fire when the grass has been ignited than if the dust did not exist among it. That the presence of dry coal dust in large quantities in the passages of collieries immensely intensifies the destructive action of explosions is a well ascertained fact and the action of the dry grass dust may well be analogous.

In making a diagonal traverse sou'-westward across the Donimalé starting from Ettinahalli traveller's bungalow, I gained the northern edge of the plateau by following a narrow path leading from the abandoned village of Virapur through the Kolla Ramen Kolla, a gorge which makes a narrow gate-like cut through a very thick bed of hæmatite quartzite. This gorge is a very beautiful object as seen from the Bhimagandi pass and nearly equally so from the lovely little valley above the gorge. The gate, which is a very narrow one, is formed by vertical cliffs from 200 to 250 feet in height, and above the cliffs steep rocky scarps rise on either side for several hundred feet higher. A clump of forest in the mouth of the gorge and rising up in front of the eastern cliff completes the beauty of a very notable corner in the Bhimagandi pass.

Kolla Ramen Kolla gorge.

East of Donimalé, and separated from it by a deep valley draining into the Narihalla outside of the synclinal, rises a high bold spur, locally known as the Wala Bhadra Konda. The northern end of it is higher than the northern end of the Donimalé and commands a good view across it, but it is not quite so high as the culminating ridge near the centre of the Donimalé. The intermediate valley, locally known as the Bardha Kolla, is remarkable for its beautiful scenery, its western side being formed by the exposure of the under side of a great hæmatite quartzite bed which is slightly inverted and which forms the eastern side of the Donimalé wedge and shows as a brilliantly red cliff. The hæmatite band which forms the summit of the great Wala Bhadra spur extends for fully 6 miles south-south-eastward till cut by a short but very fine cross gorge close to the village of Ubbalagandi.[1] This hæmatite band is the western one of a pair underlying the

Wala Bhadra Konda spur.

The great burns on the hillsides are generally set down to human action whether accidental or mischievous, but they are not always so, for I was witness on one occasion of the grass being set alight by a flash of lightning. I saw the lightning fall among the grass on a slope about a quarter of a mile from my camp at Gauripur close to the north-western end of the Raman Drug ridge. The grass began to blaze immediately and a big burn would have inevitably taken place had not a smart shower, which followed the lightning in a few minutes, extinguished the flames.

[1] Not be confounded with the great western gorge of the Narihalla.

Ettinahalli band. Their course on the north side of the great Bhimagandi gorge is but a short one, but to the south they can be followed for fully 8 miles

Ubbalagandi gate.

At Ubbalagandi this bed and the next above it are cut by the cross gorge just spoken of and a fine gate is formed, the hæmatite beds standing up as splendid red crags conspicuous for many miles to the east. Two other fine hæmatite cliffs show inside the gate, the westernmost of which represents the extension of the great inverted bed above referred to, which forms the great brilliantly red cliff which for fully four miles scarps the eastern side of the Donimalé wedge without a visible break.

South of the gate the beds continue southward for nearly a mile, but then become indistinct in their courses, owing probably to an obscure fault which appears to run across the eastern side of the synclinal, in a south-westerly direction, half a mile or so southward of the apex of the Donimalé wedge. There is here an area about a square mile in extent which needs further close study to clear up obscurity of relations between the hæmatite quartzite beds of the Donimalé and those which are to be seen in the hills north and north-east of Appianhalli. The obscurity of the section is increased by the inversion of the strata, which here also have been overturned westward.

Bardha Kolla valley.

The eastern side of the Bardha Kolla valley is formed by the extension of the principal hæmatite bed of the Ettinahalli ridge. After passing under the Narihalla, this bed forms the crest of a considerable ridge a mile in length, then it dips down again into the bed of the Bardha Kolla stream, and rises again into a subsidiary ridge forming a shoulder along the west flank of the Walabhadra ridge. It is much broken along its crest, and where it curves east, just below the summit of the Walabhadra hill it forms a castellated pile of great beauty, especially as seen by morning light. The floor of the valley is for several miles completely masked by talus from the surrounding hæmatitic cliffs and by local soil, and the intermediate rock invisible therefore, and it is doubtful whether it is a band of schist or a contemporaneous trap.

Half a mile south of the inferred fault, above alluded to, where the eastern side of the synclinal is deeply cut across by the gorge of the small stream which rises north of Appianhalli and flows north-east and eastward past Rajapoor, finally falling into the great tank at Avinamadugu, a clear section across the southern part of the Donimalé division is obtained in the gorge. The size of the stream at the present day is such as to seem quite inadequate for it ever to have cut so large and deep a gorge.

Appianhalli stream section.

The succession of formations here exposed is the following:—

9. Trapflow.
8. Hæmatite quartzite.
7. Trapflow.
6. Hæmatite quartzite, "Ettinahalli bed."
5. Trapflow.
4. Hæmatite quartzite, "Wala Bhadra ridge," western bed.
3. Trapflow.
2. Hæmatite quartzite, "Wala Bhadra ridge," eastern bed. ?
1. Trapflow. "Joga or basement trap ?"
Crystalline rocks.

East of the basement trapflow rises a set of four considerable hæmatite quartzites separated by gaps in which the intercalated strata are obscured by hæmatite talus. The relation subsisting between them and their relation to the hæmatite beds of the great synclinal are not a little puzzling, unless indeed they represent a separate series cropping out from under the representatives of the Ettinahalli beds at the eastern end of the Narihalla section, as do certain hæmatites in the Joga hills. In this case they might be actual continuations of the Saniasihalli water-fall series (see page 123) and unconformably overlapped by the synclinal series, but they are too important in size, rising as they do into ridges 800 to 1,000 feet above the high level granitoid area to the east, to be passed by unnoticed. They continue southward parallel with the Wala Bhadra Konda beds for some four or five miles, thinning out progressively till they die away before reaching the southern apex of the Sandur area. To the north they appear to be cut off by the fault mentioned above. The annexed ideal section (Plate V) offers what appears to be the most probable explanation of their general relations.

The westernmost of the four beds forms the crest of the 3,101 feet Trigonometrical station peak shown in the map, which is the highest point in the Appianhalli section of the south-eastern division.

Southern extremity of the Sandur synclinal.

South of the Appianhalli valley water-shed the broad trapflow there exposed is deeply eroded, and slopes down rapidly to the saddle by which the unfinished Kudligi-Bellary high-road crosses the southern end of the fusiform Sandur area. The stream draining this trap valley leaves the trap and cuts across the western hæmatite beds to fall into the Golia Linganhalli stream, a little above a spot determined by the Mysore Topographical surveyors to be exactly 2,000 feet above sea level.

Southerly thinning out of beds.

The various beds have thinned out so much by the time they reach the ghât road saddle that thicknesses of hundred of feet a few miles to the north are here represented by tens of feet, and as they rise again to the southward the thinning out seems to continue at an increased rate. Many die out completely, and the lower beds of the series have become more metamorphic in their appearance and are often not easy of recognition.

The "Saddle" section.

Along the road in the saddle the following succession was noted in downward succession proceeding from east to west, the eastern wall of the synclinal being apparently cut off by a great fault :—

8. Trapflow.
7. Schists, hornblendic, black and green, with granite veins.
6. Hæmatite quartzite.
5. Schists.
4. Hæmatite quartzite.
3. Schists, drab and grey.
2. Hæmatite quartzite.
1. Schist, drab and grey.

The trap westward of the schist No. 7 forms a broad belt which forms the basement of the Dharwars in this quarter. It lies upon the levelled surface of the granite gneiss of the Golla Linganhalli valley, a well-marked inclined plain very similar to that described previously as forming the eastern slope of Uchingi Drug (see pages 32 and 46).

This trap and the schists No. 7 must be reckoned to belong to the Kumáraswami division.

The extreme south point attained by the Dharwar rocks lies a few yards southeast of the 2,483 peak (Trigonometrical station) which rises 1¾ mile southward from the ghât road. Here a long narrow strip of poor hæmatite quartzite, resting direct on the granite gneiss, forms a miniature ridge a few feet high above the surrounding crystalline rocks, which in the Trigonometrical station tower up some sixty feet higher still.

All the hæmatite quartzites remaining near the southern apex are poorly ferruginous.

The highly felspathic, rather pegmatoid, granites which are seen cutting the schists No. 7 have in some cases a strong resemblance to bedded or contemporaneous trap. Where weathered, they are often hard to distinguish from the adjoining granite, where it is of a felspathic character.*

C.—The Kumaráswami, or South-Western Division.

As above stated (page 90), the Kumaráswami division includes the south-western half of the western side of the Sandur synclinal, *plus* the Devadara set of hæmatites and schists forming the bold and conspicuous ridge of that name, which has been left upstanding in the centre of the southern half of the Sandur valley.

The area measures twelve miles from north west to south-east, and about seven across its greatest width along the south bank of the Narihalla in the Ubalagandi gorge. To the south-east it tapers to a mere point, thus forming a rather misshapen triangle, the north-eastern side having an inward curve to the south, and the south-western an outward curve to the south.

As in all the other divisions of the synclinal, the hæmatite quartzites are the most conspicuous feature everywhere, though, if all the surface were clearly exposed, they would in all probability be found to occupy by no means the largest area.

No good section was met with in this division, the Narihalla section excepted: the others met with were either very short or else so imperfect, from one cause or another, as to be in great measure inferential only. Add to this the incompleteness of the maps, both the Atlas sheet (59) and the 1-inch Revenue Survey map (in the omission of several large and important ravines), and it will be easily understood that several puzzling pieces in the southern part of the division remain with their structure only imperfectly unravelled. It is unfortunate in this respect that the 1-inch Revenue Survey map of Sandur State shows only so much of Sandur hills as lies within the boundary line, every thing outside it being blank. Through the kindness of J. Cook, Esq., Deputy Superintendent, Madras Survey, I was supplied with a copy in which the hills and villages adjoining the Sandur territory on the east and west sides had been sketched in, but unfortunately not those on the south-west and south sides, where this information was really most wanted.

Insufficiency of existing maps.

As shown by the lower average of dips over the south-western division as a whole, this part of the synclinal had undergone a materially lesser amount of deformation than happened to the other parts, and no inversion of the rocks was seen in any section studied.

Kumaráswami division shows least deformation.

The petrographical characters of the different rocks met with in this division show only one feature differing from those of the other divisions, the marked absence of jaspideous character in the poorer hæmatite quartzites. It may be taken as additional evidence that the rocks here had undergone less deformation than the other parts of the synclinal, but beyond this it is a fact deserving but little notice.

Of the three great hæmatite quartzites which form the western flank of the Appianhalli narrow synclinal, and which are extensions of the Devadára group of hæmatites, the lowest one appears to have thinned out a mile north-west of the ghât road saddle above described (page 114). The remaining two can be traced about a mile and a half south-south-east, and then die

The Devadára group of hæmatitic beds.

away on the surface of the granite gneisses which here rise between 400 and 500 feet above the Golla Linganhalli valley. The last that is seen of the Dharwar rocks at the extremest end of the Sandur area is a small number of very irregular patches, from a few feet to a few inches in thickness, and of most rugged outline, and far too small in size to be shown even on a 1-inch to the mile scale, and much less on the 4 miles to the inch of the Atlas Sheet. They are many of them preserved merely because protected by surrounding irregular hummocky masses, which evidently formed part of the rugged old surface on which the Dharwar system was deposited; they had in fact been deposited in depressions in the old granitic surface.

The Devadara beds in the great spur which gives them their name are of great thickness and size, but offer no special points of interest, and the non-ferruginous intercalated beds are so greatly hidden by hæmatite talus that there is nothing to say about them.

The view from the summit of the spur is a fine one and very instructive as to the relations of the western beds of the eastern side of the synclinal, but does not convey a sufficiently good idea of the synclinal generally to be worth illustrating. The remarkably straight course of the hæmatite-quartzites along the western side of the Donimalé plateau is extremely well seen, and so is the great curve of the hæmatite beds running south-eastward from the Ubbalagandi gorge to the Kumáraswami plateau. To the north the view is very disappointing and much less picturesque than might be expected. As seen from Sandur town the Devadara spur is a bold rocky hill some 1,200 feet high above the valley and occupying a very commanding position. The ridge connecting the main hill with the eastern end of the Kumaráswami plateau is 2 to 300 feet lower than the hill itself, and close to the junction with the plateau is cut across deeply by the junction of two ravines running up from the Mudukalpenta and Nandihalli valleys respectively. A footpath that appears to be considerably frequented crosses the "col."

The Kumaráswami plateau.

The hæmatite quartzites which showed very conspicuously along the ridge are to a great extent lost sight of after joining the plateau. Only the westernmost bed

remains conspicuous for about half a mile, after which it sinks down rapidly to the south-east and its further course becomes problematical. The one conspicuous outcrop of the Devadara hæmatites here noted occurs half a mile south of Kammataravu (Cumbudhurroo) where the hæmatite forms the broad crest of a ridge some 150 feet in height, which apparently consists entirely of pure steel-grey crystalline hæmatite (specular iron) of moderately coarse texture and intense hardness. This is the richest mass of the iron ore I found in the Sandur hills or, indeed, in any Dharwar tract I have yet seen. This magnificent mass of ore appears quite untouched, the native iron-smelters being here also true to the generally prevailing custom of using only soft ores, even though comparatively quite poor, in order to save the labour of quarrying or mining and breaking up into sizes suitable for the low degree of heat they succeed in raising in their little clay-built furnaces.

Kammataravu specular iron.

To the north-west this rich ore rapidly passes into a poorer variety, such as is ordinarily met with, and to the south-east the speedy termination of the ridge which sinks rapidly into the plain is doubtless explainable on the same principle.

Except for this ridge the Kammataravu end of the plateau is very level, and its surface entirely hidden by local pseudo-laterite and thick red soil.

The upper of the four Devadara hæmatites skirts and in fact forms the eastern edge of the plateau for several miles, and, after forming a short and very low ridge to the north-west of Appianhalli, sinks gradually as it runs along the ridge west and south of that village. The lowest of the four hæmatite beds does not appear to be represented in the Appianhalli western ridge. If it is, it has thinned out so greatly as to have become perfectly inconspicuous, unlike the three upper beds, which show strongly at the northern end of the ridge, but the lowest of these three, as pointed out at page 117, thins out and disappears before reaching the southern extremity of the synclinal.

The Devadara hæmatites are underlaid by a great contemporaneous trapflow, which occupies a wide space in the valley around Sandur town and fills great part

The Sandur trapflow.

of the Nandihalli valley (the south-westerly fork of the main valley), but which narrows greatly to the south-east in part, apparently, from actual thinning out, but in part also from the strata of all kinds being there tilted up at much higher angles than further north.

Underlying this great trap formation, the "Sandur trap" of the Narihalla section, and forming the south-western side of the Nandihalli valley, which, along the northern edge of this part of the Kumáraswami plateau, rises very steeply, and is in places distinctly scarped, comes the great series of hæmatite quartzites we became acquainted with in their north-western extensions in the Raman Drug division. They do not at all diminish in size as they sweep round south-eastward, from the great Ubbalagundi gorge, and are very conspicuous objects till they get past the Kumáraswami Trigonometrical station hill,[1] when they trend south-eastward and sink down rapidly into the level southern half of the plateau, and are speedily lost under a superficial pseudo-lateritic formation. Whether their disappearance is caused by a change in the mineral character of the beds cannot be ascertained. The Trigonometrical station hill is the highest point in the Sandur hill group, and according to General Cullen, as quoted by the Schlagintweits, measures 3,400 feet above sea level.

View of the Sandur valley.

The most interesting, and by far the most picturesque, view of the Sandur valley is one to be got from the edge of the plateau between the Kammataravu iron ridge and the eastern end of the Trigonometrical station ridge. One of the beds here forms a precipitous scarp of very lateritoid rock some 30 feet high, that enables one to get a clear view over the thick jungle which here covers the slopes. The eye ranges from here up the valley for some 12 or 15 miles, and can make out a large number of points in the collocation of the beds which form the Devadara ridge, the western side of the synclinal and the intervening traps and schists of the Sandur valley. The view is one that

[1] The Kumaráswami Trigonometrical station hill is given in sheet 59 as "Mulla Ammanhuroo." A name which is evidently a corruption of Malla Amman taravu, the name of a small temple and tank lying a little to the south-west of the hill.

The peak does not appear to have any distinctive local name, probably because not at all a striking object in the landscape.

could not be rendered happily by photography, as the many small ridges appearing in the background would be utterly lost. A sketch would have been feasible, but would have required far more time than I had at command. To have done justice to a view exhibiting such an immense quantity of detail in all its parts would have involved several days of hard work.

The Kumáraswami temple.

To the north of Kumáraswami's temple, one of the most popular shrines in this part of India, the hæmatites are cut into rather deeply by the small but exceedingly picturesque ravine which opens into the Nandihalli valley. Another very lovely spot is to be seen a few yards off the road about half down the good ghât road which the Rajah of Sandur has lately finished and which makes it quite easy to ride up to the temple. Two beautiful bluffs of hæmatite rising out of a gorge richly wooded and ornamented in the wet season with several pretty waterfalls are here to be seen and admired.

The temple itself is externally a plain stuccoed building of very moderate size. Only the ghât part of the road was finished at the time of my last visit in 1889; but when the intermediate piece of road is completed, it will be easy to visit the temple in a long morning's ride. The temple is itself not architecturally worth a visit, but the geology of the route to be traversed is of considerable interest. A little to the eastward of the temple, a white and purple clayey schist is dug out from under one of the hæmatite bands and shown to the believing Hindus as the fossil remains of the milk which flowed from the breasts of the goddess Parvati as she wandered disconsolately over the mountains in search of her lost son Kumaráswami!

Adar Gani gorge and iron mine.

The lower beds of the hæmatite series rise to a considerable height in the ridge west-north-west of the temple, but they offer no specially interesting features at that place. Further west the plateau is deeply cut into by a large and deep gorge, the northern scarped side of which is formed by the lowest of the great beds and by underlying red hæmatitic argillites, which being very bare of vegetation give the whole hill side a conspicuously

red colour. The very steep slopes bear little but a thin jungle of small wild date palms (Phœnix farinifera?), around the roots of which are to be seen thousands of large reddish wormcasts where grass ought to be growing. My visit being in the hot weather, the authors of the wormcasts were not to be found; they had retreated far down into the depths, so their zoological alliance could not then be ascertained for want of tools to dig them out. In no other part of the Peninsula have I seen such vast traces of worm work.

On the north slope of the gorge and about 1½ miles west by north of the Kumaráswami temple, and a third of a mile east of the centre of the curve the hæmatites describe, lies an old iron mine known as the "Adar Gani," from which soft but rich hæmatite is still raised and conveyed on pack-bullocks to two smelting centres, Kannevihalli in Sandur State, three or four miles (by the path) to the north-west, and Shiddagal, 15 miles to the south in Kudligi taluq.

The bed from which the ore is raised is deeply weathered, and I did not get sight of the unweathered rock, so cannot say what it may be exactly like. The overlying rocky ridge is an ordinary hæmatite quartzite. Judging by their weather-beaten appearance the old workings must be of considerable antiquity. The new workings now in progress are on a smaller scale than the old ones. They lie on the slope some 2 to 300 feet below that of the Kumaráswami plateau, and paths lead from them up to the temple and the village of Subrayanahalli and down along north-westerly to the foot of the hills to the south of Kannévihalli.

Tonashagiri hæmatite series.

To the south-west of Subrayanahalli and south and south-east of Kumaráswami's temple the southern scarped edge of the plateau is formed by the outcrop of an important hæmatite quartzite for a distance of some 7 miles. Another bed very similar in size and quality underlies the above bed and keeps parallel with it all along the slight scarp into the Tonashagiri spur. Here both beds descend the eastern slope, and trending from west-north-west to east-north-east cross the mouth of a large and deep ravine (very badly shown in the atlas sheet and not at all in the 1-inch

Madras Survey map) and extend to the north of Tonashagiri village, beyond which their course becomes quite obscure, probably because they thin out. I could not trace their continuation round the Tonashagiri corner into the Appianhalli ridge.

Above and overlying these two beds, which I will call the lower Tonashagiri beds, another hæmatite bed crops out, and where it is crossed by the path from Tonashagiri to Kammataravu it contains numerous thin lenticular concretions of a manganese ore similar to that seen on the ghât west of Raman Drug. Similar concretions occur in the same bed about half a mile further westward, where it is crossed by the direct path leading from Kammataravu to Somahalli. The concretions in this upper Tonashagiri bed are not so black in colour as those seen near Raman Drug, and are more earthy looking and therefore probably poorer in quality.

Manganiferous bed.

Owing to the great spread of lateritized detrital hæmatite on the very level of the southern part of the plateau the stratigraphical relations of the Tonashagiri and Raman Drug series of hæmatites could not be determined in that quarter. As seen in the spur north-west of the iron mine valley, the former certainly appears to be simply a lower series which is widely overlapped by the upper one.

The iron mine series of red argillites is underlaid by a series of grey ones, which is crossed by the path leading from the mine to Kannévihalli.

About a mile below the Adar Gani mine the path, which has been running down the eastern side of the spur, crosses a slight saddle and passes along a bed of drab argillite, in which occur numerous large and small concretionary nodules of a black manganese ore (see Chapter on Economic Geology). The nodules are larger and of much deeper black colour than those met with to the west of Raman Drug and constitute a richer ore which from its situation could be very easily and cheaply mined. The argillite bed has a dip of 40° N. E.

Manganiferous nodules in argillite.

Iron and manganese are the only metals that were met with by

me in the Sandur hills. Traces of copper, lead, and antimony are reported to have been found in the State, but none were seen by me, and the localities where they occurred not being given in the Bellary District Manual, I could make no special search for them.

Crystalline limestone.

A little further down the path runs across argillite weathered to a dirty brown colour, in which occur many strings of calcite which when freshly fractured, show greenish, reddish, and white tints. Close to a little jutting knoll may be seen a bed of compact grey crystalline limestone running in the strike of the argillites. It has a thickness of from two to three feet. Just beyond where the path gets on the flat at foot of the hills a little ridge rises to the left. This consists of a whitey-grey quartzite having a dip of 50° E. N. E.

Caves.

The overhanging scarp of the great hæmatite quartzites (of the Raman Drug series) to the south-east of Kannévihalli shows some large cavernous recesses. Newbold, in his account of the geology of Sandur, mentions some caves as occurring under the lateritoid rock on the Kumaraswami plateau. I did not come across them, and my guide knew nothing of them; so, as Newbold mentioned their not having statagmite flours, I did not spend any time in hunting for them.

Underlying the Tonashagiri hæmatite series is a schist series which in its turn rests upon a great thickness of contemporaneous trap which, in the Tonashagiri corner, forms the base of the Dharwar system. Further west this trap is underlaid by a considerable series of schists of various kind, which may be fairly well seen in a section to the northward of Saniasihalli. The section here shows the following succession underlying the fine horse-shoe cliff over which the stream, coming down from the Subrayanahalli plateau (the western end of the Kumaraswami plateau), makes a fine fall in the rainy season. The water-fall cliff appeared to me to represent the lower of the two great Tonashagiri hæmatites:—

Saniasihalli section.

7. Hæmatite-quartzite, "Horse-shoe cliff."
6. Dark-green schists.
5. Greyish black flaggy beds.

4. Hæmatite.
3. Trappoid.
2. Trap.
1. Schists in great thickness (grey, etc.).

The Tonashagiri hæmatites die out, I believe, before trending round the south-western corner of the hills. They underlie the manganiferous argillites and the limestone and quartzite mentioned above (page 123). The general dip of all the formations around this corner is from 40° to 45° north-east or northward.

The position occupied by these beds relatively to the whole Sandur series resembles the position which (as will be seen further on) are occupied by four other sets of formations which all underlie or appear to underlie the great Joga trapflow, which plays so important a part in the area lying between the Sandur and the copper mountains synclinals. The four sets in question are the "outside" group of hæmatites east of the Appian end of the synclinal (p. 116), the Joga hills series (p. 126), the Lingadahalli series (p. 127), and the Mallam Konda beds (p. 130), all of which seem to be to some extent unconformably overlapped by the Joga trapflow and the yet younger great hæmatite series.

Schists near Somulapur.

To the west of Somulapur, opposite the western mouth of the great Ubalagandi gorge, the Dharwars consist of hornblendic, micaceous and chloritic schists which were deposited on a very hummocky granite gneiss surface, giving rise to a very rugged fringe of boundary impossible to be shown in detail even in maps on the largest possible scale. Many of the large hummocks of the granite gneiss have their tops exposed, while their bases remain covered by the schists which lap round them.

Talcose schists are also to be seen here and there to the west of Somulapur, but in much lesser quantity than at the other localities enumerated above. Only the Atlas sheet No. 58 was available at the time I mapped this tract, and on such a minute scale it was not possible to show the many changes of schist met with.

To the south of Somulapur the boundary of the Dharwars became increasingly ragged, and a long narrow strip of green hornblendic schist juts out like a peninsula for more than a mile and stretches

across the bed of the Narihalla, which here flows in a very pretty valley between low rocky hills both of schists and granite gneiss.

The main boundary of the Dharwars lies half a mile to the east of this, and from here onwards south-eastward loses its ragged character but continues ragged for a couple of miles or more to the northwards.

The Somulapur potstone.

Somulapur, a small half-abandoned village, just within the border of Kudligi taluq, and half a mile south-west of Kannévihalli, is partly supported by a small industry in potstone vessels, which are made with some degree of skill. The potstone occurs in beds close to the base of the Dharwars, and is quarried to a small extent in a quarry pit nearly circular in shape and about 30 feet across. Three beds of potstone are seen—

3. A coarse green bed of inferior quality.
2. A grey middle bed of good quality and alone used.
1. A coarse green bed resting on the underlying gneiss which is seen a little to the west. The industry will be described in the chapter on Economic Geology.

These Somulapur potstone beds are the only ones in the Bellary district positively known to belong to the Dharwar system.

B.—The Joga-Sultanpur area.

The tract lying between the Sandur and the Copper mountain synclinals, which I call the Joga-Sultanpur area, from two villages at its western and eastern extremities respectively, is very largely occupied by a series of trapflows, which lie very near the base of the whole Dharwar system.

Basement schists and hæmatites.

With the traps, but underlying them, are some schists and hæmatites which appear to be really the base of the system. A few unimportant schist and hæmatites and one small limestone bed occur intercalated between the trap flows, and prove by their position that the trap was not one vast flow, but represents a succession of minor ones, separated only locally by the very small sedimentary deposits just named.

In the centre of the trap area the trap rises into hills from 300 to 400 feet above the surrounding plain.

The trap is generally a very dioritic rock of very black colour and medium texture. Here and there it is coarse grained. A slight tendency to prismatic (columnar) jointing is not uncommon, but the columns are rarely more than a foot long and rather rude in shape.

A narrow margin of the basement trap along the western side of the area has been included in the fold of the Sandur synclinal, and on the edge of this margin stands the village of Joga, which is one of the most interesting centres for the study of the Dharwar rocks, as is clear from a consideration of the three important sections in the three ravines opening south of the village (see pages 101-106). These do not exhaust the geological interest in the environs of Joga, for within a few yards of it to the north runs one of the largest and most important trap-dykes in the Bellary district forming two elevated ridges crested with great piled-up masses of intensely black rock which present quite dominant features in the Joga valley; while immediately north of the great dyke rises a considerable and important hill mass which, for want of a local name, I will call the Joga hills.

These hills consist of thick beds of schist and hæmatite quartzite underlying the great trapflow, which may very conveniently be termed the Joga flow from the important position it occupies in the valley and along the southern slopes of the Joga hills.

Joga hills section.

The section afforded by a traverse over the Joga hills from north to south is the following:—

12. Trap-flow, "Joga flow".
11. Schists.
10. Hæmatite quartzite, very thick.
9. Trappoid.
8. Hæmatite quartzite.
7. Chloritic schist.
6. Hornblendic schists.
5. Chloritic schists, ferruginous.
4. Trappoid, very thick.
3. Hæmatite quartzite, poor.
. Hornblendic schist, thick.
Hæmatite, rather earthy, very thick, dark colour.
Gneiss.

The dip of the lower beds on the northern slope varies from 65° to 70° southward. The hæmatites appear to be only local, and to thin out both to the west and east.

The eastern extension of the schist beds in the low tract between the hills and Bassuapur (Bussuapoor) is very greatly obscured by a thick cotton soil spread.

Limestone near Tallur.

To the south-east of the Joga hills, a little to east of the junction of the Joga nullah with the Narihalla, is an exposure of schists with a few small beds of creamy white or grey crystalline limestone. The schists may be traced eastward across the Narihalla a little north of Naglapur, where they include a small bed of hæmatite quartzite.

The relations of these schistose rocks to the surrounding trapflows are much obscured by thick cotton soil, and it is not quite certain whether they are to be considered as an inlier of the Joga series exposed by denudation of the traps locally, or as a small separate series intercalated between two great trapflows. I am inclined to adopt the latter view provisionally.

The country all around this little schist exposure is formed of trap which is seen in countless little outcrops and numerous shallow sections in different stream beds, but there is nowhere a good deep section in which to study the peculiarities of the rock. Westward of the Narihalla it extends right up to the foot of the Sandur synclinal and dips under the lowest hæmatites there seen. South-eastward of the Narihalla the trapflows disappear for a short distance, and there is a show of schists

Lingadahalli schists.

which stretches away south-eastward up the valley of the Lingadahalli nullah to the boundary of the gneissic area against which they are faulted. The trapflow re-appears to the north of the schist band and rises into rounded hills which stretch away to the south-east.

The relation of these schists, to the trapflows around, is by no means clear. The schists along their southern side appear to overlie the "Joga" trapflow, which is continuous under the great Ettinahalli hæmatite bed, but they show no hæmatites worth mentioning and

cannot by any possibility be correlated with the rocks in the Wabhadra Konda spur and Donimalé, for it is quite improbable that the great hæmatite beds characterising the eastern wall of the Sandur synclinal should have disappeared within the distance of a mile or little more. Despite, therefore, the appearance these schists present of overlying the Joga trapflow, the most reasonable conclusion is that they really underlie them, and are equivalents of the Joga hills series, but without the great hæmatites.

The Lingadahalli schists consist largely of pale chloritic schists and grey argillites, with here and there small bands (thick laminæ) of crystalline limestone.

The hills lying north of the Lingadahalli schist tract are made up of trap of the "Joga flow" overlaid by several other trappoids and traps all very similar in character, but with here and there small intercalations of schists (chloritic and hornblendic) and hæmatite which clearly prove the trap masses to be of different ages. The trapflows immediately north of Lingadahalli are traversed by the great dioritic dyke already noticed as being close to Joga, and which may be named after the village at its south-eastern extremity. It forms a high and conspicuous crest towering well above the trapflows it cuts through. These latter are coarse grained, mottled black and white with their hornblendic ingredient arranged in rather elongated fibrous bundles. The great dyke consists of ordinary green and white mottled granular diorite. No good section of the contact exists, but the dyke, as far as can be seen, has had no effect on the rock they cut through. This observation applies equally to the relations of the great dyke and the flows it traverses along its long course north-westward past Joga.

The Avinamadagu trap dyke.

To the north-eastward of the dyke-crested hills lies a rather deep valley which divides the southern hilly part of the Joga-Sultanpur area in two: at its northern end lie the ruins of an abandoned village formerly known as Hattigenhalli. About a mile east of the northern end of this valley, I came upon a small bed of highly crystalline limestone intercalated between

Hattigenhalli limestone.

two trapflows. It was much obscured by talus and long grass, and could only be traced for a short distance. The outcrop was remarkably weathered.

The northern slope of the eastern hilly tract sinks down into a very level plain so thickly covered along its southern side with talus[1] and cotton soil that it is impossible to determine the boundary between the Dharwars and the granite gneiss within half a mile. The boundary appears to run nearly due east and west, and in the south-eastern corner of the plain where it cuts the Avinamadagu nullah, a small rise in the ground brings up a patch of schists with a backbone of poor hæmatite quartzite which forms the southern extremity of a small anticlinal ellipse which dips under the basement trapflow. It is of interest only as a probable equivalent of the Joga hills and Lingadahalli schists.

Basement trapflow south of Sultanpur.

To the south of Sultanpur the basement trapflow forms a rather rocky hill with a steep scarp on the western side down to the granite gneiss. To the east the trap extends in an uninterrupted spread across the Avinamadagu nullah and up into the hills, in which it becomes a portion of the Copper mountain synclinal.

The hills of the Joga-Sultanpur area have been entirely denuded of trees to supply Bellary town with fire-wood, and at present they only support long grass and scattered bushes despite the richness of the soil formed by decomposition of the highly basic traps. The hills are mostly rounded in shape and large protruding masses of rock are rarely seen.

C.—The Copper Mountain, or Suggammadevibetta synclinal.

This long and narrow folding of the Dharwars is connected with the Sandur synclinal by the broad spread of contemporary trap just described, and this trapflow is in its south-eastern extension included in the folded area.

[1] Consisting mainly of coarse trap *débris* and very largely cemented by kankar into a sub-aërial agglomerate.

The Copper mountain offers a much less interesting succession of rocks than does the Sandur synclinal. This is partly owing to the fact that the sections are much less perfect, rendering it far from easy to correlate the several members of the two synclinals, or even to feel perfectly certain as to the identity of the principal beds at the opposite ends of the synclinal. This is a difficulty that must exist in areas where the strata have been contorted and fractured, and contain neither fossils nor minerals whose distribution is sufficiently special to admit of their being used to determine horizons.

Tumati section.

The most interesting section across this narrow and greatly squeezed-up synclinal is to be traced from the north-eastern corner of the great tank at Avinmadagu, north-eastward for a distance of about 5½ miles at right angles to the axis of the synclinal and at a point nearly equidistant from the extremities of the great fold. The line of section passes but a little eastward of the village of Tumati, after which I will call it.

The succession of rocks obtaining here is the following :—

South-west wall of synclinal.	*North-east wall of synclinal.*
11. Hæmatite quartzite.	11. Hæmatite quartzite.
10. Schists, hornblendic, &c.	10. Schists, hornblendic.
9. Hæmatite quartzite.	9. Hæmatite quartzite.
8. Schists, hornblendic, &c.	8. Schists, hornblendic.
7. Hæmatite quartzite.	7. Hæmatite quartzite.
6. Schists, hornblendic, &c.	6. Schists, hornblendic.
5. Hæmatite quartzite.	5. Hæmatite quartzite.
4. Schists, hornblendic, &c.	4. Schists.
3. Trap, a broad belt.	3. Schists, a great thickness of black and green hornblendic.
2. Hæmatite quartzite.	2.
1. Schists, dark hornblendic.	1.
Granite gneiss.	*Base not seen.*

The beds forming the north-east wall of the synclinal are slightly inverted, while those of the centre are vertical and those of the south-west wall have a very high northerly dip. I cannot help thinking that only the basal part of this exceedingly deep synclinal fold now remains; the upper part, which included many of the beds represented in the Sandur synclinal, having been denuded away bodily,—in fact, only about half of the whole series has been allowed to remain. The

hornblendic schists alternating with the hæmatite beds appear to represent the contemporaneous traps which form so striking a feature in the north-eastern and southern walls of the Sandur synclinal. Owing to their having undergone far greater pressure in the Copper mountain synclinal, the trapflows have been converted into hornblendic schists.

At the eastern end of the synclinal where the compression was much less, as shown by the much smaller angle of dip of the hæmatites in the Mincheri hills, the traps have only been partially "schistified" (if such a word is allowable), and appear variously as nearly unaltered trap, as a trappoid of semi-schistose character and as true schists, but generally cut up into small masses by an infinite number of small joint planes, often at right angles to the great cleavage planes.

Mallam Konda series.

At the base of the series forming the south-west wall of the synclinal lies a great thickness of dark hornblendic schist overlaid by a great bed of hæmatite quartzite which in its turn dips under the "Joga" trapflow. The hæmatite quartzite which is a strong, thick bed forms the crest of a broad lofty ridge, which is separated from the main Copper mountain range by the wide and deep valley of the Tumati stream, and further east by a deep ravine opening to the south into the Hirrahal valley. The summit of this ridge is known as the Mallam Konda and is the highest point in the range after the Copper mountain. These Mallam Konda schists and hæmatite quartzites are doubtless the representatives of the Joga hills series, as are also the schists and hæmatites exposed in a small inlier above-mentioned, which is exposed by the denudation of the lowest bed of the Joga trap 1½ mile north-north-west of Sultanpur. Mallam Konda is hidden from Bellary town by the main range, but is well seen from the top of the Fort hill.

Hargandona north-west section.

The most important section north-westward of the Tumati section occurs at the bend made by the hill range some four miles to the north: the succession of rocks here seen is the following: —

12. Green brown schist, chloritic?
11. Hæmatitic, decomposed.

10. Schist, micaceous.
9. Argillite, fine grained, dirty green, brown, chocolate.
8. Schist, hæmatitic, dirty looking.
7. Schist, argillo-micaceous, pale greenish-brown.
6. Conglomerate, quartzose pebbles in argillo-micaceous matrix.
5. Schists, argillo-micaceous.
4. Ditto, micaceous.
3. Schist, black hæmatitic, dirty.
2. Schist, with hornblendic bands.
1. Trap, contemporaneous, very thick.

This series appears to represent only the south wall of the synclinal, the beds at the eastern base of the section being slightly inverted to the west. The eastern wall of the synclinal is obscure and difficult to make out because the hæmatite quartzites all die out in the ridge north-north-west of Hargandona[1] (Hurgandody of sheet 58), and the merely schistose beds do not admit of identification and correlation.

The range makes a great trend here from north-north-west to west-north-west for a couple of miles, but then resumes its former course to the north north-west.

Section south of Budikanama ghât.

To north of the second bend the following succession of beds occurs, as the ridge (which by this time has greatly decreased in height and continues to decrease gradually northward) is crossed at a point about half a mile southward of the Budikanama ghât. The section runs east to west—

7. Hornblendic schist, very shaley (? weathered ?).
6. Hæmatite quartzite.
5. Hornblendic schist.
4. Hæmatite quartzite.
3. Hornblendic schist.
2. Hæmatite quartzite, small bed.
1. Trappoid, broad band. Prismatic jointing seen at intervals.

Trap show west of Kudatanni.

Between the eastern end of the section and Kudatanni new tank (not shown in sheet 58) lies a tract thickly covered with great blocks of black trap. This I showed in the map as a great trap-dyke, but I am now inclined to think that it represents the surface of a great trapflow lying at the base

[1] A village with a similar name (Hurgoondona) is shown in sheet 58 about 2½ miles to the north-east by north, but no such village exists, nor seems ever to have existed except in the imagination of the chartographer.

of the hæmatite series of the great synclinal. The great and thick spread of cotton soil which covers the face of the plain renders the settlement of this question difficult.[1]

To the northward of the Budikanama ghât the synclinal has again become recognisable, a couple of hæmatite quartzites reappearing with the same slight inversion to the west in the position which theoretically they ought to occupy as continuations of the hæmatite quartzites which, as shown above, died out in the hills south of Kudatanni. In little more than a mile and a half, however, the hæmatite quartzites die down again not to reappear, and the synclinal character of the band in its northerly extension ceases to be obvious; indeed, the north-eastern wall of the synclinal is entirely lost under superficial deposits.

The western wall of the synclinal continues quite distinct for several miles till the ridge sinks down into the valley of the Narihalla, which is here dammed up to form the noble Darôji tank.

The western hæmatites, which at the Budikanama are four in number, diverge at the northern end of the first break in the ridge, the two easterly ones running down the northern slope and disappearing from sight under surface deposits about a mile to the north. The two westerly ones, on the contrary, rise again into a good-sized ridge which continues to the south end of the Darôji tank. These hæmatite quartzites are locally a good deal contorted and their dip doubtful.

Very small veins of white magnesite appear commonly in the south-eastern half of the ridge, and are very conspicuous where traversing the (locally) black bed of hæmatite. Their occurrence here is remarkable, for there is nothing to account for their presence,—no signs of thermal water action, as is the case with those in the so-called Chalk hills near Salem and elsewhere in that district and Trichinopoly district.[2] The veinlets of

Magnesite veins on Suji Konda.

[1] The nullah which rises close to the southern end of this trap formation does not flow due north, as shown in sheet 58, but trends north-north-west after crossing the Bellary-Dharwar road and flows into the Timapur stream. This fact is somewhat important in connection with the distribution of Dharwar rocks *débris* over the granitoid plain north of Kudatanni.

[2] See Memoirs of the Geological Survey of India, Vol. IV, p. 90, (on the Geology of Trichinopoly, Salem, and South Arcot. By William King, and R. Bruce Foote).

the magnesite are very irregular in size, swelling out suddenly in places and here and there assuming the appearance of nodules.

At the foot of the southern end of this section of the Copper mountain ridge, which is locally known as the Suji Konda, the lowest member of the Dharwar series is the Joga trapflow, which is here very thin, and dies away a little distance further north-north-west when the lowest hæmatite quartzite, which widely overlaps the trapflow, rests directly on the surface of the granite, which is here of the highly porphyritic Bellary type. The actual contact is to be seen here and there where the talus has been washed away. The contact between the two rocks is perfectly sharp and distinct, and it is manifestly only a case of superposition of the hæmatite quartzite. There is not the slightest alteration in the character of the hæmatite at the contact, and the two rocks do not adhere.

Contact of Dharwars and granite.

Newbold, though in general a sound observer, propounded the idea that the great schist series had been broken through by the granites, and mentions cases of the direct intrusion of the latter into the schists both on a large and small scale. Had he seen this section I don't think he could have misunderstood it. What misled him was his not having recognized the fact that there are younger granites which ntrude into the older granitoids and the overlying Dharwars as well. Nowhere did I find the old granitoids behaving irruptively towards the Dharwars, but everywhere the latter show that they had been deposited quietly on the rugged or smooth surface (as the case might be) of the old crystallines.

The hæmatites in the north-western half of the synclinal are, as a rule, poorer in iron than in the south-eastern half, but here and there an exceedingly rich stretch occurs in one of the beds. A good example of such a rich stretch occurs on the Suji Konda before named.

Suji Konda hæmatites.

Outcrops of hæmatite quartzite, the extensions of the eastern of the two great beds forming the crest of the northern end of the ridge, occur in the line of the bund of the great Darōji tank. Near the

village of Darōji the base of the Dharwars is ill seen, but in the low hill half a mile north of the village the basement bed seen in contact with the granite is trappoid in character and doubtless represents a re-appearance of the Joga flow.

Section north of Darōji.

The section seen in the hill shows the following beds along an east to west line:—

11. Trappoid hornblendic schist.
10. Greenish and black schist.
9. Quartzite hæmatite, poor.
8. Schists, trappoid, black.
7. Trap, hornblendic, coarse granular.
6. Trappoid.
5. Trap, hornblendic, coarse granular.
4. Quartzite, schist, grey, green.
3. Trappoid.
2. Hæmatite quartzite.
1. Trappoid, very thick bed.

Granite gneiss.

The Dharwar rocks here rest upon a rather smooth inclined plane similar in character to that forming the eastern slope of the Huchingi Drug ridge, and to that dipping under the Dharwars at Golla Linganhalli at the south-eastern extremity of the Sandur synclinal. The eastern end of the section disappears under surface deposits and is completely lost to sight. The correlation of the beds here seen is quite problematic. It may represent the whole synclinal, in which case the numerous hæmatite quartzites forming the two walls of the fold further to the south have died away, all but one on each side. The two traps, 5 and 7 of the section, are identical in appearance, and strongly suggest the idea of their being the sides of one and the same folded bed.

Contact of the Dharwars and granitoid.

The basal trappoid is well seen at foot of the Hala Dehwalapur Drug hill, a very bold, picturesque crag of dense pale grey granite gneiss. The contact of the trappoid and underlying granitoid is well seen along the curve of the hills between Dehwalapur and Darōji. This is one of the places which Newbold mentions as affording evidence of the irruptive character of the great mass of the granitoids. As a matter of fact,

however, such is not the case. The injected veins are not branches of the granitoid mass, but veins of pegmatite which permeate both the granite gneiss and the Dharwar trappoid. An injected mass of the pegmatite of appreciable size lies several yards within the trappoid mass in one place. The trappoid here also shows no trace of alteration in contact with the old granitoid floor, and I am quite at a loss to understand Newbold's comparison of this contact corner with MacCulloch's classical section of the granite intrusions at Cape Wrath.

Rocks north of Metra.

The northernmost extremity of the schist band, as seen to the north of Metra along the high road to Kampli, consists of dark schist, as does the small outlier 2 miles to the north-west, and also the small outlier at Devasundra 3 miles north-north-east of Metra, which forms a link between the Copper mountain synclinal and the Kampli patch of Dharwars, which is really a westward extension of the Pennér-Haggari band.

Green quartzite.

South-east of Metra, a few score yards beyond the high road, rises a low ridge of impure quartzite in thin beds, much of which shows a delicate green stain. The stone somewhat resembles a green avanturine and would make a pretty material for inlaid stone-work of the Agra type, or for mosaic work. The whole eastern side of the Darōji extension of the synclinal is immensely obscured by cotton soil, and the boundary itself absolutely hidden everywhere, but is doubtless a faulted one, the Dharwars being thrown down against the granitoid.

Section at the Tumati-Bellary ghât.

To return eastward again and follow the range to the east of the Tumati section above given (page 130); several points of interest occur along the half finished ghât road leading to Bellary. The ghât runs east to west mainly along the south side of the axis of the range, which rises several hundred feet above the watershed. To the south of the watershed the range is much lower; the schists and trappoids which there compose it have been denuded to a much greater extent than the hæmatites to the north. This schisto-trappoid tract is, except along the course of a few streams which have cut themselves shallow ravines, briskly undulating, almost

too much so to be classed as downs, and quite bare of forest, supporting only grass, and is one of the principal ramnas which supply the cavalry horses in Bellary with hay during the hot weather.

The trappoids and schists here seen are evidently the extension of the trap and schists Nos. 3 and 4 of the Tumati section, which are themselves extensions of the trapflows and schists occupying the Joga-Sultanpur area. The grassy undulations of the schisto-trappoid tract extend south-east to the south-eastern extremity of the great spur which runs south from the Sugammadevibetta peak (the Copper mountain proper). Here the trappoids stop out and are overlapped by the overlying hæmatite quartzite series which forms the sides of the synclinal further eastward.

The hill lying north of the Tumati-Bellary ghât, which is the second highest point in the main range, is crested by two great beds of hæmatite quartzite; a third lies on the southern slope; while three others run at intervals along the northern slope. The space between the southern bed and the southern of the two cresting ridges is occupied by argillaceous, hornblendic and chloritic schists, some of which are conglomeratic and contain large pebbles of granular quartz, many of which have been much deformed by lateral pressure and show a distinct tendency to cleavage. The cresting beds show a dip of 85° north-east by north in parts, and are vertical at other points along the crest.

Conglomerate beds.

Rather more than 1½ miles south-east of Haragandona (Hurgandody) is a valley opening to the north-east, the mouth of which has the form of a huge gateway which has lost its lintel, and which, from its great size, forms a striking object as seen from the north. The gate posts are formed by the projecting ends of a great hæmatite quartzite bed. As no place of note lies near it, and I could not ascertain that it had a local name, I will speak of it as the "Iron Gate"—a name which is certainly not inappropriate. The Iron Gate lies about ⅘ths of a mile westward of the northern end of the Tumati section.

The Iron Gate section.

The section here displayed is a rather interesting one, as it shows

something of the structure of the synclinal fold near its centre and in a part where it is but slightly deformed. The section runs from north-east to south-west in the bed of a wide ravine which cuts the rocks to the depth of from 300 to 400 feet:—

11. Schists, micaceous, very coarse in texture, with red spots.
10. Hæmatite quartzite.
9. Schists, hornblendic and chloritic.
8. Hæmatite quartzite.
7. Schists.
6. Hæmatite quartzite, thin.
5. Hornblendic schists, thin.
4. Gritty beds, altered, micaceous matrix.
3. Hornblendic schists.
2. Hæmatite quartzites, "Iron Gate" bed.
1. Schists, hornblendic, etc.

In the southern side of the synclinal the section is much less distinct, only the hæmatite quartzites showing up distinctly because of their superior hardness. The upper hæmatite quartzite in the north wall of the fold is slightly inverted to the southward.

The altered grit beds No. 4 of the "Iron Gate" section consists of a silicio-micaceous matrix of rather gneissic appearance, in which are imbedded innumerable grains of clear quartz. These beds form a group of considerable thickness.

Of the beds seen in this section the hæmatite quartzites Nos. 10 8, 6 and 2 may, I think, be safely correlated with the iron beds Nos. 11 9, 7 and 5 in the Tumati section; the two cresting beds of the high hill north of the Tumati-Bellary pass (see page 137) correspond with 10 of the Iron Gate section and its replica in the south wall of the synclinal. The gritty beds No. 4 in this section seem to be the representatives of the gritty and conglomeratic beds of the Tumati-Bellary ghat section above described.

Country north-west of Haragandona.

The Iron Gate bed dies down to the southward of Haragandona and is lost sight of, but another hæmatite bed appears to the north-west of the village in a corresponding position with reference to the rest of the series, and rises northward to form the scarpy western side of the double ridged hill which lies north-north-west of Haragandona. The higher-lying hæma-

tite quartzites show in full force in the Gabbigudda, the hill mass lying between Haragandona and Sultanpur, and the lowest of them there rests directly on the Joga-Sultanpur trap which rises into hills from 400 to 500 feet high over the plain. Owing doubtless to the fact that they have been greatly tilted and lie at very variable angles, the trapflows of this region never show any tabular forms such as are so characteristic of the trapflows of the great Deccan trap and so many other trappean region. The Dharwar traps weather into round-topped hills and undulating plains.

Sugammadevibetta.

Turning eastward again we come to the Sugammadevibetta or Sugalamma Konda, as the highest peak in the range is called by the Kanarese and Telugu people respectively, the Copper mountain of the European residents of Bellary. No good section is here available; the northern scarp is too precipitous to be scaled in a direct line, and the southern slope is greatly covered up by talus and long grass, owing to which there are several large gaps in the succession of beds to be made out, and these gaps can only be filled inferentially by studying the slopes at some distance to the east and west. The hill is a fine one from all sides, showing as it does so many fine cliffy scarps of great height. The summit is to a great extent covered by a hard quasi-lateritic sub-aerial crust of hæmatite *débris* cemented by a ferruginous cement. This is the main cause of the sterility of the summit, but further down, where the schistose and trappoid beds occur in great thickness and weather into rich soils, the absence of trees is due only to mischievous human agencies.

The easiest way to ascend the mountain is by the path which runs south from Bellagal past the artillery practising ground, and then zig-zags up the hill to the south. On reaching the top of the spur the path turns to the east, and continues rising steadily at an easy angle till the last ascent is reached, when the angle becomes a steep one. Quite half the distance can be done on pony back in ascending. There are distinct paths leading from the summit to two other places, namely, Halakundi on the Bellary-Bangalore road and Wobalapur (Woltapur of

sheet 59). The ascent by these two paths is much more laborious than *vid* Bellagal, but even they do not offer any real difficulty to an active man, despite what is said about the inaccessibility of the summit in the District Manual.

The view from the summit is a noble panorama with a radius of from 60 to 70 miles on clear days. Starting from east by south, the eye passes from Guti Drug to Gampinal Konda, and the hills south-east, south and south-west of Anantapur, thence to Pāgarh, Nidigal, Konderpi Drug, Joga Maradi, Chital Drug, and Guheshwar, all of which are over 50 miles distant. At the extremity of various but much shorter radii from the Sugammadevibetta are, to the south-east and south, Boglemar Konda, Kona Kondla, Udarapi Drug, Kalyan Drug, Raya Drug, Kailasa Konda, Molakalmuru, and to the south-west Jerramalla.

To the westward the table-topped mass of the Sandur hills breaks the horizon; to the north-west lie the granitoid labyrinths of the Anagundi hills beyond the Tungabhadra and of the Hampi-Daroji hills on the Bellary side of the river; to the north of them, the Jadigudda hills, and the Maski hills show on the horizon in the Raichur Doab, and further eastward the Bhanur hills; to the north-east the Adoni hills and to the south-east of them the granitoid labyrinth south of Patti Konda leads the eye back to the starting point at Guti Drug. Intermediate between these distant northern and north-eastern hills are the equally rocky groups of Kurgode, Tekkalkoté and Alur. Many other smaller rocky granitoid masses lie scattered about on all sides and many of them have an archæological interest as well a geological one, as they were formerly inhabited by the neolithic and early iron folk, who left on them many traces of their habitations and of the industries they pursued. Among these the following deserve special notice: The Hatti Bellagal and Ram Drug to the east-north-east; Latwaram hill, Urava Konda, Budi Konda, Yelapadugu, and the Iddapinkal hills to the south-east. Close to Bellary are the Kapgal and the two Bellary hills, all three of which were pre-historic neolithic settlements of great interest, and the first, the seat of a great manufacture of polished stone implements.

As already pointed out, the great features of the mountain are the scarps formed by the great hæmatite bands which here crest the main ridge, and of which the two southernmost and the most northerly form the crests respectively of the two great easterly spurs. The deep bay which has been eroded between these spurs appears to owe much of its size and importance to the stopping out of the summit bed a little to the eastward of the summit. The east side is very deeply eroded, and the spurs after running one mile or so to the south-eastward sink down into the Halakundi pass through which the Bellary-Bangalore high road runs.

Halakundi pass.

The pass separates the main range from the eastern part of the synclinal, which is known as the Mincheri hills, The pass is divided into two narrow valleys by a low ridge which lies in the middle, and on the back of which are exposed numerous outcrops of beds which are hidden by thick superficial deposits in the two adjoining valleys. The section here displayed is unfortunately not perfect, as owing to superficial deposits several considerable gaps occur in which no rock at all is seen. Starting southward from the bridge south of Halakundi village, the following series is to be seen in ascending order as far as No. 7, then in descending order :—

13. Hæmatite quartzite, very poor, coarse grained.
Gap of about 20 yards.
12. Hæmatite quartzite, very thick.
11. Micaceous beds, dirty green.
10. Hornblendic trappoid.
9. Gneissoid, dark, greenish brown.
8. Hornblendic schist.
7. Trapflow, dioritic.
6. Hæmatite quartzite, varying from rich to very poor in iron.
5. Siliceous gritty schist, blue grey.
4. Trappoid dark "birdseye."
3. Hornblende schists, greenish black.
2. Trappoid dense, black. Gap of 200 yards.
1. Hornblende schist, very siliceous.
Gap of 50 yards.
Gneiss, pink felsitic.

The hæmatite quartzite No. 6 is the continuation of the great bed

forming the great cliffy middle spur of Sugammadevibetta. The southern half basement bed seems to be a hæmatite bed overlapping directly on to the granitoids without the intervention of the Joga-Sultanpur trap series which has died out to the westward. The central and southern parts of the section cannot at present be correlated with the beds on either side of the pass.

The Mincheri hills.

The connection between the Mincheri hills and the Sugammadevibetta beds is very obscure except at the north-western corner. The great mass of the hills is formed of hornblendic schists and trappoids, which occupy a median position with regard to the axis of the synclinal and lie quite at the top of the series.

The connection of the beds east and west of the pass is chiefly determined by the extension of the hæmatite quartzite No. 5 of the Halakundi pass section, which may be followed for the best part of 3 miles eastward, but is then lost sight of. The underlying hæmatite, not seen in the pass section, though very well marked on the northern slope of the northern spur of Sugammadevibetta, becomes very strong to the south of Mincheri and Chenurayankoté, and continues of important size and fair richness all along the north-eastern slope of the hill group to its south-eastern extremity. A yet lower hæmatite bed, which is locally very rich in iron, shows immediately south of Mincheri village, and again as basement bed along the northern base of the hills. About a mile and a quarter west-north-west of the south-eastern extremity this basement hæmatite, which may conveniently be known as the Mincheri bed, is cut across by a large and important trap-dyke.

The whole of the central part of the hills appears to consist of thick beds of trap and trappoids, which rise into rounded down-like hills devoid of trees, though the soil is fairly rich almost everywhere.

South side of the Mincheri hills.

Two important hæmatite beds skirt the greater part of the south side of the Mincheri hill group and terminate in the southern extremity at Nemkal, where there is an interesting section that will be described further on.

To the west these two hæmatite beds are cut off short by a fault, westward of which occur the beds that form the southern portion of the Halakundi pass section. These beds have trended to the south-east and disappear to the east of Hirdahal (Hirahal) under the cotton soil as the ridge they formed dies down.

The rocks westward of the fault are not easy to understand in their correlation with those further to the east or west. Like those at the south end of the Halakundi pass the hæmatites are rather poor in quality.

Section across the hills north of Hirdahal.

A traverse across the highest part from south-west to north-east shows the following succession of formations :—

8. Hornblende rock.
7. Gneissoid quartzite, bluish, flaggy.
6. Hornblendic schist.
5. Trappoid schist, thick.
4. Hæmatitic beds.
3. Semi-pegmatoid, bluish, reefy.
2. Hornblendic schist.
1. Micaceous schist, grey, greenish with flakey inclusions of decomposed felspar.

Owing to thick soil the base is not seen locally, but at a little distance are outcrops of the ordinary archæan granitoid. The basement micaceous rock shows in small low bluffs along the western foot of the Hirdahal ridge.

Green gneissoid.

In the corner made by the Hirdahal ridge and the faulted western end of the Nemkal hæmatite beds is a show of green gneissoid rock which from its position appears to be of Dharwar age. Its green colour, which chiefly affects the quartz, is due to copper, and gives a very beautiful appearance to the rock, which has considerable resemblance to the green micaceous rocks so highly valued for mealing stones by the neolithic folk which had their settlements at and around Bellary. Fragments of it occur frequently in the great banks of angular *débris* which lie along the boundary of the Dharwars from the corner eastward towards Antakal.

To the east of Nemkal village, at the south-eastern extremity of the synclinal the Dharwar rocks have been deposited, abutting against a steep southern slope of the very rugged granitoid foundation. The following formations are exposed in this section :—

The Nemkal section.

21. Hornblendic schist and rock.
20. Hæmatite quartzite, altered? whitish drab colour, weathers dirty pink.
19. Hæmatite quartzite, thick, hæmatite laminæ much limonitized.
18. Ditto schist.
17. Quartz rock, granular.
16. Hornblendic schist, dip 55° N.
15. Ditto ditto, dip 45° to 50° N.
14. Gneissoid schist.
13. Micaceous gritty schist.
12. Hornblendic schist.
11. Gneissoid quartzite.
10. Hornblendic schist.
9. Micaceous gneiss, coarse.
8. Hornblendic schist, thin.
7. Quartz, intrusive?
6. Hornblendic schist, thin.
5. Micaceous gneiss, coarse.
4. Hornblendic gritty schist, thin.
3. Gneiss with nests of greenish mica schist.
2. Hornblendic micaceous schist, coarse, well bedded in parts.
1. Gneiss, coarse, well bedded? archaic gneiss?

The annexed diagram (Plate VI) gives an approximate representation of the section which shows various formations not commonly met with in the Dharwar system, and such as were not met with to any extent in the other parts of the Copper Mountain synclinal nor in the Sandur or Mallapan gudda bands. All the gneissoid rocks in the above section come under this category, but they differ yet more from the typical granitoids, and they are, moreover, in such a situation stratigraphically that they can only be reckoned part of the Dharwar series, unless, indeed, they be regarded as part of a younger gneissic system which lies conformably to the true Dharwars. The existence of such a younger gneiss series is not as yet positively proven, but it may yet have to be established when the subdivision of the crystalline rocks has been proceeded with further, as it assuredly will be on closer examination by future observers.

4. The Pennér-Haggari band.

Only a section some 38 miles in length of this great band of Dharwar rocks lies within the limits of Bellary District and stretches south-east from the right bank of the Tungabhadra at Naddevi to a point some 6 miles south-east of the railway crossing over the Haggari river, where the band passes on into the Anantapur district. This elongated strip of the Dharwar rocks is connected with a large and most irregular-shaped patch of schists and trappoids which extends up the valley of the Tungabhadra as far as Kampli, but the connection is outside of Bellary district by the extension of the band on the left bank of the river. Four small outliers of the same rocks occur also to the east and south of Kampli town.

Unlike the other bands this section of the Pennér-Haggari band is not at all hilly, a peculiarity apparently due to the almost entire absence of hæmatite quartzites. In the few places, however, where such rocks do occur, the band immediately becomes hilly, as in the cases of the Sindigiri hills, and the small hills near Naddevi, Bailur (Byloor), Kagal (Kuggall), and again in those of the Joladarashi and Chellaguriki (Chelgoorky) ridges east of the Haggari. The only other eminences within the band are a low black rocky hill of trappoid half-way between Bellary and the Haggari river, and a couple of low ridges of blotchy trap running in three parallel closely contiguous dykes a couple of miles to the south of the Chellaguriki ridge above named. The further extensions of the bands, however, both in the Raichur Doab and in the Anantapur districts are generally more or less hilly, and frequently very much so; and this is always coupled with the appearance of hard bands of some kind, the most frequent being hæmatite quartzites.

The Kampli patch.

The shape of the patch in the Tungabhadra valley can hardly be described, but a glance at the map will immediately explain its complexity. The rocks forming this Kampli patch consist very largely of trap flows, trappoids, hornblendic and chloritic schists, with here and there a small hæmatitic bed. Intrusive veins of pegmatoid granite are very common. A goodly show of these is to be seen in the left bank of the large Yemmiganur nullah, 6 miles east of Kampli town.

Some of the granites occurring among the schists in this quarter appear to be contemporaneous. Striking examples of such are to be seen in the banks of a small nullah draining the high ground immediately north-east of Kampli; also on a somewhat larger scale in the banks of a nullah which falls into the Tungabhadra 4½ miles north-east of Kampli. These granite flows are best seen where the road from Kampli to Itugi crosses the nullah.

Contemporaneous granites.

The village of Devasundra, 4 miles south-south-east of Kampli, stands upon an outlier of dark schists (hornblendic?), the area of which is quite uncertain owing to the extensive spread of cotton soil which surrounds the place and hides everything effectually. This outlier is a link between the Kampli patch and the northern end of the Copper Mountain ridge.

Devasundra outlier.

To the north and north-east of Kampli the schists and trappoids cross the Tungabhadra into the Raichur Doab, where they form, roughly speaking, three triangular patches with their bases abutting on the river. The north-eastern patch of these three abuts on the continuation of the main band into the Doab and Hunugunda sections of it. Its southern part near the river shows a great development of black trap strongly resembling parts of the Joga-Sultanpur trapflows (see page 129).

The beds seen in the banks and bed of the Tungabhadra, where the main band crosses it, are chiefly dark hornblendic schists and trappoids. To the west of Naddevi a fairly rich hæmatite quartzite band forms a low ridge which runs under the old keep which forms the western fortification of the village. The beds are distinctly seen to cross the river into a small detached hill on the Nizam's side of the river, but they there become poor in iron and speedily disappear in the general mass of schists. To the south they disappear under the cotton soil when the ridge they formed has died down to the general level of the country. The eastern side of the band is greatly obscured by cotton soil and the outcrops are very few and far between. At the great bend the Tungabhadra makes below

Naddevi ford section.

(north-east of) Naddevi a strong reef consisting of pale green (chloritic) schist crosses the river. There is a great show of the green schist on the bank. To the east of these pale green schists, green hornblendic schists show up with a few thin beds of poor variegated hæmatite schists.

The central part of the band further south, where crossed by the path leading from Sirrigiri to Tekkulkota, shows small obscure outcrops of argillite, which in a small nullah about three-quarters of a mile west of the eastern boundary has assumed a strongly flaggy structure and shows a measurable dip of from 55° to 60° east by north. Very generally the dips of the schistose beds are not to be distinguished with any certainty from the cleavage planes which frequently run parallel, or nearly so, with the strike. The whole of the eastern boundary of the band from the bank of the Tungabhadra to the place where it crosses the boundary between the Bellary and Anantapur districts is greatly obscured by the great cotton soil spreads which cover by far the larger part of the Bellary taluq. It is only here and there, at intervals of a few miles, that the schists on the eastern side of the band are exposed for short distances by the eroding action of the streams which flow across the band, and mostly from south-west to north-east, *e.g.*, to the north-east and south-east of Sanawaspur. The predominant form of schist met with is hornblendic, of variable character and appearance; but chloritic schist and argillites of pale colour crop up here and there.

Sindigiri hills.

The only hills worthy of the name which occur in the Bellary section of the Pennér-Haggari band are the Sindigiri hills which occur on the western side of it, some 15 miles due north of Bellary. They extend about 4 miles north-west by north from Sindigiri and form a single ridge, which rises about 400 feet (or less) over the plain about the centre (or a little to the south of it) of the ridge. As already mentioned, the Sindigiri ridge is due to the presence of two or three rather important beds of hæmatite quartzite moderately rich in iron. The bedding is a good deal contorted and tumbled, and near the top of the ridge certainly inverted in many places; but the true general dip appears to be easterly.

Here and there they are jaspideous ; but at other places the rock shows a decided tendency to become schistose. The hæmatite quartzites are underlaid by micaceous argillites, greenish drab or greenish grey in colour.

Other hæmatite beds.

Two miles south-east of the southern end of the Sindigiri hills rises a hill of very slightly hæmatitic quartzite which, though low (only about 100 feet high above the plain), is remarkable for its bare and rocky character and very artificial appearance, due to the peculiar nature of the jointing which affects it and gives it from the east the appearance of a gigantic palisading. The strike of the bed is northerly with a slight trend westward at each extremity and the dip is easterly at angles of from 75° to 80° east.

Two miles further south and about three-quarters of a mile south-east of the village of Dammur is a moderately large and rich bed of hæmatite quartzite, which occupies a position in the band approximately the same as the bed above named as far as can be seen ; but nothing positive can be ascertained owing to the tremendous cotton soil spreads which intervene and cover everything. These two outcrops appear to occupy a much higher position in the series than that of the Sindigiri hæmatites which, like the Naddevi hæmatite, are low down near the base of the series.

The band widens considerably and is fully 6 miles across abreast of Korlagundi, but then narrows again where it trends eastward. Only trappoids and hornblendic schists with a little pale chloritic schist are here exposed, the former to the south-west and the two latter at and around the village of Korlagundi.

Very little is to be seen of the Dharwar rocks in the section of the band lying between Korlagundi and the Tungabhadra, near Chaganur : the country is low and flat and greatly covered by cotton soil or shingle beds of undetermined age. To the south and south-west of Chaganur exposures of trappoid are fairly numerous, *e.g.*, a green hornblendic trappoid shown in the bed of the nullah north-west of Budihal.

Bevinballi trappoid hills.

About half-way between Chaganur and Bellary lies a low, bare, rocky hill of reddish brown and black colour, consisting of a dense hornblendic trappoid

containing many segregations and strings of quartz, which is frequently stained green by the presence of pistacite. The run of the rock seems to be north and south, or perhaps 5° of north, but there is no recognisable foliation and no regular system of jointing. A similar rock, apparently an extension of this Bevinhalli (Bavinhully) trappoid appears on the south side of the railway close to the old high road a little south-west of the village. To the south-east and west the trappoid is speedily hidden by cotton soil, and how far it may extend in these directions it is not easy to determine.

A little beyond (north-east), the second milestone from Bellary on the Karnul high road, a small exposure of hornblendic trappoid is to be seen protruding over the cotton soil. It is probably a small outlier of the Pennér-Haggari-Dharwar band. Many very small granite veins have been intruded into the trappoid and intersect each other freely.

Exposures east of the Haggari near Lingadaviranhalli.

The Dharwar rocks make no show in the alluvial valley and bed of the Haggari river. They probably consist of softish beds which have been too deeply eroded by the river in former times to protrude above the recent alluvium and the line of blown sand-hills which skirts the right bank of the river. Very little is seen of them away to the eastward of the river bank, from the same cause presumably. It is only along the south edge of the band to the east of Lingadaviranhalli that there is a noteworthy show of hornblendic and chloritic schists with unimportant beds of poor hæmatite quartzite. The schists show chiefly along the right bank of the large nullah which falls into the Tungabhadra half a mile north of the village.

Chloritic schists show at intervals from Lingadaviranhalli eastward all over the southern half of the band, but of the northern half very little is to be seen because of the great spreads of cotton soil which conceal the face of the country almost completely. It is almost only along the northern edge of the northern half of the band that outcrops of rocks are to be seen. The most conspicuous of these are a ferruginous band with its associated over and underlying schists, which form

a ridge broken into three low hills; between the north-western and central of which, at Joladaráshi (Joladaraushy) 4½ miles east of the Haggari railway bridge, the old Bellary-Madras high road passes. On top of the third and lowest of the hills stands very conspicuously the village of Chelguriki (Chailgoorky).

Joladaráshi Iron bed.

The ferruginous bed which forms the crest of the three hills is more schistose than is often the case, and only in parts does it appear quartzitic. The ironstone is mostly limonitic, and brownish instead of reddish in colour. South-eastward of Chelguriki this ferruginous ridge dies down, and all is hidden by cotton soil at the boundary where the band enters the Anantapur district. In the Joladaráshi hill, the central one of the three, it is under and over-laid by brown argillites. The argillites on the south side, *i.e.*, underlying it, are on the hill west-north-west of Joladaráshi hill of pale buffy or drab colour, and contain a number of very small hæmatitic beds only a few inches thick. The main iron bed here, which appears to be the extension of the crest bed on the Jaladaráshi hill E. S. E. of the village, has not the limonitic character seen in the crest bed, but is hæmatitic and jaspery in texture, poor in iron, and much contorted and vandyked on a small scale. The general dip is doubtfully northward and there may possibly be an inversion of the strata.

A few miles further to the east-south-east a hæmatitic bed reappears, occupying a corresponding position in the band.

The character of the western boundary of the Pennér-Haggari band is, wherever seen, that of a natural erosion boundary, but that of the eastern boundary appears to be a fault or series of faults causing the Dharwars to abut against the old crystalline rocks. It cannot be positively asserted that the general boundary line is formed by a number of faults, but it is a very legitimate inference from the facts to be observed as the band is followed up. That faults exist in places is, however, perfectly certain.

Nature of the boundaries.

All the dips seen are eastward and at right angles to the general course of the band except in one solitary outcrop of schists in the bed

of the nullah east of Korlagundi, which nullah drains the north side of the Bellary hills. Here the dip is westerly at a high angle, but this may very likely be due only to a small local inversion.

Sanawaspur section.

The best section across the band seems to be that from the top of the Sindigiri hæmatite ridge in an east-north-east direction close past the village of Sanawaspur. Nothing is seen after leaving the hæmatite ridge but a succession of schist, hornblendic chiefly, but with a little micaceous argillite. The hornblendic schist shows up to within a few feet of the coarse red massive granitoid against which it is faulted.

The easterly succession of schist outcrops seems quite undisturbed, and as they are also at high angles must represent a thickness of many hundreds of feet, which can only be accounted for by a great let down to the east.

Owing to the extraordinary extent to which the generally low and flat surface of the Dharwar rocks in the Bellary section of the Pennér-Haggari band is covered up by superficial deposits, and especially by the great and continuous cotton soils pread, it is impossible at present to understand the stratigraphical relations subsisting in many parts of the band, and unless some extensive artificial sections should be made by consequence of the construction of great engineering or mining operations, there seems little chance of much additional light being thrown on the structure of this much obscured tract of the old schistose rocks. Unfortunately there seems no probability of any such great engineering or mining works coming to pass in this part of the Bellary district.

The same degree of obscurity as to the structure of the south-easterly continuation of the band into the Anantapur district continues to prevail till the hilly tract which it forms in the valley of the Pennér is reached, and there the rocks are for a considerable distance disposed in a synclinal fold, the southern extremity of which remains as yet unexplored.

5. Eruptive Rocks in the Dharwar Areas.

Though very numerous and conspicuous from their position and colour, the intrusive rocks met with in the several Dharwar areas yet occupy no very great area, and are of no great economic value. They may be referred to the following four groups: —

(*a*) *Contemporaneous granites.*

(*b*) *Pegmatite veins.*

(*c*) *Brecciated Quartz-runs* ("*fault rocks*").

(*d*) *Trap dykes.*

Of these the last is by far the most important in every respect.

(*a*) *The contemporaneous granites.*

The contemporaneous granites are rather similar petrologically to the pegmatites to be described further on, but they do not cut across the bedding of the schist as do the latter, but appear to lie quite conformably between the associated schist-beds. They are best seen in the bed of a small nullah (about a mile S. W. of the mouth of the Nari Halla) where crossed by the road from Kampli to Itugi (Ittagay). The granite-flows lie between beds of grey gritty schist which have a gentle roll to the eastward.

The Itugi Section.

Another section in which several such contemporaneous granites are to be seen occurs in this neighbourhood. It is formed by the small nullah flowing westward from a low ridge ½ a mile N. E. of Kampli town. The granite-flows and the schists they are intercalated with are seen to be practically parallel with and conformable to each other.

The Kampli Section.

(*b*) *Pegmatite veins.*

Veins of a size large enough to be shown in the map are of very rare occurrence, but smaller ones are in parts very common, but have no influence on the character of the rocks they traverse. They have, however, been mistaken by some geologists for intrusive veins emanating from a great granite-uprising by which the schistose masses of the

Not veins from a general granitic mass.

Dharwar system were supposed to have been upheaved, contorted and riven in every direction. This was the view advocated by Newbold in his Summary of the Geology of India and reproduced by Dr. Carter in his Summary given in the Geological Papers on Western India.

That such is not the case I have already pointed out when dealing with the contact of the Dharwars and the granite to the northward of Daroji (p. 52) where the veins, seen traversing the trappoids and hornblendic schists of the extension of the Copper Mountain synclinal, are not branches of a granitoid mass penetrating into the Dharwar rocks, but veins of a far younger pegmatite, a rock differing much from the granite petrographically and as much irruptive in it as it is in the adjoining schists. Newbold's comparison of the well-known remarkable show of granite veins at Cape Wrath with these veins north of Daroji is simply unintelligible.

Pegmatite veins in the bed of the Tungabhadra, W. of Hospet.

The most noteworthy example of the pegmatite veins is that to be seen on the right bank of the Tungabhadra where an extension of the Sandur synclinal fold crosses the river. The pegmatite veins here form a group of four, of which two lie close to the western side of the synclinal, a third crosses from the village of Mellapur to Honnur Malai (Honoor Mully) on the northern bank, and the fourth, which lies about half a mile to the north-east of No. 3, crosses the southern branch of the river to the island in the middle of the stream beyond which its course was not visible from the south bank. The river is not fordable even at low water and no boats were to be obtained by which to cross, so I had to leave the northern ends of the veins unexamined.

These veins differ from the ordinary pegmatites met with in the granitoid region in having the quartz and felspar ingredients in very equal proportions and in being of fairly uniform texture throughout.

Where not discoloured ("black-leaded") by the action of the river-current the reddish pegmatite makes a strong contrast with the dark, almost black, trappoid which forms the principal mass of the Dharwars crossing the river. The veins have been curiously and

deeply eroded, and much polished by the river which here descends rapidly and forms a violent rapid.

Veins crossing the Tungabhadra below Kampli.

A couple of large pegmatite veins of similar character cross the Tungabhadra just 3 miles N. E. by N. of Kampli (Kumply) and form dyke-like reefs in the bed of the river.

(*c*) *Brecciated Quartz-runs* ("*Fault-rocks*").

A very small number only of these remarkable dyke-like masses of quartz have been actually intruded into the Dharwar rocks, but several occur along the boundaries of the Sandur hills and Copper Mountain tracts in positions in which they may well be regarded as fault-rocks.

Quartz-runs intruding into the Dharwars.

The examples of intrusion of these quartz-breccias into the Dharwar rocks area are three in number, and two of them occur near the northern end of the Copper Mountain area to the north of the village of Daroji. They lie 1½ and 2½ miles respectively northward of the village, and the northern of the two forms a small steep crag capped by a small temple. The crag is of the usual pale creamy to reddish or buffy white colour, its course is W. N. W.—E. S. E. for about 1½ mile, and both ends disappear under cotton soil.

The more southerly of the runs strikes a little south of east for a distance of about 1½ mile where, like the first named, its ends disappear under the cotton soil.

The third case is a quartz intrusion within the limits of the Penner-Haggari band 2½ miles S. S. E. of Naddevi (Nuddavy) on the Tungabhadra. The run rises in the middle of a great cotton soil spread, and no contact with the schists or traps of the Dharwar series it has been intruded into is visible.

Quartz-runs as boundary fault-rocks.

There are three cases of boundary fault-rocks of brecciated quartz, each visible for about a mile along the southern boundary of the Copper Mountain tract, but they are of no special interest. They occur at

intervals of 4 miles; the most north-westerly about a mile E. of Antapur, the most south-easterly to the N. of Hirrahal, and the central one a little south-east of the Mallam Gudda peak.

Kudal quartz-run.

Part of the southern boundary of the Joga Sultanpur band uniting the Copper Mountain and Sandur hills tracts is formed by an important quartz-run which passes close to Kudal (Koodall) and forms a considerable hill. Unfortunately no contact with the trap-flows forming part of the Dharwar area immediately north of the fault-rock, nor with the great Avinmadagu trap dyke, was found; so the exact relations of the intrusive quartz with those rocks could not be observed.

At the western end of the run where the brecciation of the quartz is not well marked, and a remarkably close-set series of nearly vertical joint planes simulate true bedding planes very successfully, the rock might very easily be mistaken for a very highly metamorphosed quartzite.

Hospet Hill fault-rock.

The largest and most important quartz-run on the boundaries of the Sandur area occurs only about 2 miles eastward of the point where the Dharwar rocks cross the great rapid in the Tungabhadra. This run which is best, though very ill, seen a couple of hundred feet or so up the N. and N. E. flank of the Jannel Rashi, the Hospet Trig. station hill, forms the north-western end of the north-eastern side of the synclinal fold. This run certainly seems to be in the position of a true fault; for the very strong and conspicuous hæmatite beds which form the mass of the Hospet hill and are the extension of the great eastern series are suddenly cut off on the northern slope and cannot be traced any further to the northward. The position of this quartz-run with reference to the Dharwars composing the Hospet hill is quite clear, but owing to the great amount of talus on the slope the contact relations of the two rocks cannot be seen sufficiently to allow of their being studied to any advantage.

Another quartz-run occupying the position of a fault-rock occurs on the S. W. side of the Sandur area at a place called Sanassyhalli, but here again it was not possible to see any contact phenomena between the Dharwar schists and the quartz rock.

Sanassyhalli fault-rock.

In the Mallapan Gudda (Chiknayakanhally) band of Dharwars, two cases of quartz-runs in the position of boundary fault-rocks were mapped: one at Mudanur (Moodanoor) two miles, and the other seven miles to the south-east of Huvina Hadagalli (Hoovin Huddagully). Here, again, no visible contact between the quartz and the country rock on either side of the fault could be found. The second of these two runs gives rise to a steep ridge standing up about 200 feet above the plain. To the east of it, but at a considerable distance, granite rocks crop up, while to the west a great show of trappoid occurs on the broken ground stretching away towards Varakanhalli, only at some distance from the quartz-run.

Mudanur and Varakanhalli fault-rocks.

(*d*) *Trap dykes.*

The age of very many of the numerous dykes shown on the map is still unsettled; and only those which are *bonâ fide* eruptives into the Dharwar system, can be with safety assigned to the post-Dharwar period.

Of a limited number only can it be asserted that they had existed prior to the commencement of the deposition of the Dharwar rock system. The evidence in favour of their age is negative, they are not seen to cut through schists, hæmatites and contemporaneous traps making up that system.

Of much the largest number of dykes met with in the Bellary district, the age cannot as yet be determined, for they are not in contact with the Dharwar rocks; but some of them may possibly have penetrated the portion of those rocks now denuded away, which lay between the present bands and outliers, and connected them. Others, again, of greater age, may have been intruded into the

Archæan granites and gneisses long before the commencement of the Dharwar era.

No striking dissimilarity in external appearance was noticed, except in one special case, between the rock material of the dykes unquestionably intruded in post-Dharwar times and those which appear to belong to the pre-Dharwar era. Whether a close petrographical and microscopical examination of all the dykes will allow of such age difference being determined in this way, is a question remaining to be answered by further research. The special case mentioned above, in which marked dissimilarity of character of the rock was noticed, is that of a group of dykes penetrating the Dharwars of the Pennér-Haggari band in the valley of the Haggari river, which is described further on (p. 164).

Number of post-Dharwar dykes.

The number of dykes noted as cutting the Dharwar rocks is 36, of which three are possibly doubtful, and may prove possibly to be of pre-Dharwar age, which formed high upstanding ridges, around and over which the Dharwar rocks were deposited on the surrounding old archaic surface.

Only the large or otherwise important members of the number will be named separately; and in considering them, it will be most convenient to take them serially from west to east.

Dykes in the Kunchur tract.

Of the dykes cutting the Dharwar rocks in the Kunchur tract of the Shimoga band, one of the largest, and at the same time one of the most interesting, is that which runs north-west towards Holal from Tharada and contains included masses, which appear to be fragments of the granitoid it was protruded through.

Another great dyke which lies some five miles to the north-east of Holal and passes close west of the village of Virapur, is deserving of some little notice from the intense blackness of the surface rocks, and their rather scattered and detached arrangement along the strike of the outcrop which, but for the unconformity of the argillites it passes through, might well be mistaken for a narrow flow-outcrop.

Uchingi Drug dyke.

A large dyke which cuts through the Dharwars or stands up "inlier fashion" surrounded by them, and traverses the Uchingi side band (p. 167) diagonally from south-east to north-west, next requires notice, because of its doubtful relations to the country rock, no contacts with which could be seen unfortunately.

Dykes in the Mallapangudda band.

Proceeding northward to the Mallapangudda division of the Dambal-Chik Nayakanhalli band, only two dykes of interest were observed. They occur on the eastern side of the band to the west of Maithur (Mydoor) in the Harapanahalli taluq. The first of them forms two striking ridges of

The north dyke at Maithur.

black large-blocked hornblendic trap (diorite?) which run nearly parallel with the eastern boundary of the Dharwars from Maithur north-westward and then north-north-westward for 10 miles close up to Varrakanhalli. In the middle part of its course it sinks down below the cotton soil spread lying to the south of Nandi Bevur, and is covered up for nearly a mile; only cropping out at intervals. In the southern part of its course it presents much of the appearance of being a trap-flow uptilted to a high angle and running parallel to all appearance with the trappoids, hornblendic schists, and poor hæmatitic beds, which make up the mass of the Dharwars in that corner. In the northern half of its course it presents the ordinary sharp-cut appearance of a true dyke. Its southern end is cut off by an important fault immediately west of the village of Maithur, while its northern end is lost sight of in the trap-flow forming the hilly corner east of Varrakanhalli.

The Maithur south dyke.

At its southern extremity it appears to abut, nearly at a right angle, on the great south dyke, which is a genuine intrusive dyke of post-Dharwar age. The contact of the two dykes is unfortunately, however, invisible. This southern dyke runs west-south-west from close west of the village of Maithur, and traverses the Dharwars to high up on the eastern flank of Jajkalgudda.

At the extreme south end of the Sandur synclinal a large dyke shows cutting through the basement beds of the Dharwars locally, and running up north-westward past Golla-Linganahalli and disappearing finally in the basement trap-flow a little to the east of Tonashagiri village. No contacts were to be seen here. To the southward of the extreme end of the synclinal, the great dyke trends south-east and crosses the Rampur spur of Mysore territory (over which I did not follow it up). It is possibly the extension of the great Kailasa Konda dyke west of Raya Drug which runs down south by east to the Haggari river which it crosses, and may be followed by the eye for many miles further south. If the two dykes are really continuous, they measure over 38 miles in length, and are of great size. The dykes rise in many high blocky crests of jet black colour, and are very conspicuous.

In the Sandur area. Golla-Linganahalli dyke.

Proceeding north-eastward from Golla-Linganahalli to the Copper Mountain synclinal, a large dyke is found to the north-west of the Sugadevibetta peak which runs in a south-west by west direction. Its eastern end descends the northern spur of the peak; and trending to east by south, crosses the Bellary-Bangalore road near Halakundi, and disappears under the cotton soil a couple of hundred yards west of Mincheri. The dyke at this point has diverged northward just outside the boundary of the Dharwar area; but about a mile further east by south what appears to be a continuation of it rises again and forms a high well-marked outcrop which trends south-east by east, re-enters the Dharwar area in the Mincheri hills, and continues in it for nearly a mile and a half and then dies down at the south-eastern extremity of the Copper Mountain synclinal, and is finally lost sight of under the cotton-soil plain. The dyke consists of black diorite (?), and measures some 13 miles in length along its curve.

The Copper Mountain dyke.

The only other remarkable dyke in the Copper Mountain band is a very large and broad but ill-defined one lying a mile and a half west of Kudatani, and about the same distance east of the Budikanama Ghat. The dyke

Great dyke west of Kudatani.

shows as a band of large detached shapeless blocks of black diorite (?) which form no crest, but lie about as if part of a flow, for which it would certainly be taken, but that it cuts across the schists diagonally in a north-west by north direction. It shows for a distance of four miles and its course is parallel with that of a large and conspicuous dyke lying east of Kuditani and its apparent extension four miles further to the north-east,— near Timapur.

The Kapgal dyke.

Another large and important dyke which cuts through the Dharwar rocks is the great Kapgal dyke whose south-eastern end some 7 miles E. N. E. of Bellary disappears under the alluvium of the Haggari at Teggin Budihal. Here no sections could be traced showing whether the dyke was intrusive or whether the Dharwars had been deposited around an old trap ridge standing out over the denuded granite surface.

The north-western end of the Kapgal dyke forms a very conspicuous band of black rock on the northern face of the Kapgal hill itself and is remarkable as a dyke that has weathered more quickly than the granite country it was irrupted into, and has therefore given rise to the formation of a cliff of the granite some 80 to 100 feet high above its own surface instead of itself forming a black ridge rising high above the surrounding granite rock as is usually the case.

The dyke extends with wide breaks far to W. N. W. The part of it occurring on Kapgal is of great interest to archæologists as having once been the site of a great industry in the manufacture of celts, very large numbers of which were found by me, and later on by other pre-historic-implement collectors, in all stages of manufacture. The stone specially used was a paler. fine-grained trap occurring in lenticular masses, often of large size, in the dark dioritic looking mass of the main dyke. On some of the blocks, too, a number of grotesque figures are chipped into the stone; some of which are supposed on good grounds to be of pre-historic origin.

The granite cliff left at the east end of the hill by the more rapid weathering of the trap is a perfectly sharp-cut mural cliff and forms

a very conspicuous object in the landscape when seen from the east.

South-eastward of the Kapgal hill, the dyke becomes obscure, as it has been eroded down to the general level of the country rocks both within the gneiss area and the Dharwar area, and is here and there much covered up by superficial deposits. It can, however, be easily followed down to the edge of the Haggari alluvium at Teggin Budihal (Boodyall).

To the N. W. by W. of Kapgal, the dyke can be followed for a mile W. N. W. beyond the hill, and then it becomes obscured by cotton-soil and is only seen again at two intervals, each at about three miles distance south of Somasamudra and north of Yerra Inglagi.

Blotchy Trap dykes south of Virapur Railway Station.

In the Bellary section of the Pennér-Haggari band is a very interesting group of dykes of remarkable character which consists of three large and conspicuous dykes, the eastern extremities of which stretch away for more than a mile into the Anantapur district.

The dykes lie four miles south of Virapur Railway Station on the Southern Mahratta Railway and form two ridges about 100—150 feet high above the bordering cotton-soil plain, with a course of about 5° N. of W. The special character of these dykes is their extraordinary porphyritic structure, containing as they do millions of large rounded enclosures of pink or pinkish white felspar, from ½ to over 2 inches in diameter in a green matrix, which give the rock when seen from a distance the strongest likeness to a coarse pebble bed. The visible length of these dykes is about four miles. The enclosed felspar masses are not at all amygdaloid in character.

Permadevanhalli dyke.

A single dyke of precisely similar character and colour runs along the south side of the Bellary-Madras road for about a mile, about half-way between Permadevanhalli and Joladarashi. Its course is the same as that of the three dykes just described, but it stands up so little over the cotton soil surface as to be very inconspicuous, but has been blasted to some

extent to furnish material for inverts and road revetments near its eastern end. It is the very toughest rock I ever tried to break, but the felspar has been weathered to a considerable depth nevertheless. Two other small patches of similar trap occur about a mile to the north of this dyke. A very small protrusion of similar blotchy trap is to be seen immediately north of Chaganur on the left bank of the Haggari. It looks very much like an extension of the Permadevanhalli dyke, but if it be so the course of the dyke has made a great trend to the north-west. No other shows of similar trap are known to me anywhere else.

CHAPTER VI.

INTRUSIVE ROCKS IN THE ARCHÆAN AREA.

As will be seen by a glance at the map, and as has been pointed out in the last chapter, large numbers of intrusive rocks, chiefly in the shape of trap dykes, some of them of great size, occur scattered all over the Archæan or Granito-Gneissic area in such positions with reference to the Dharwar system that their relative ages cannot be determined at present, while a mere macroscopic examination of their texture affords no satisfactory help in this matter. Beside the trap-dykes (A) are a considerable number of runs of *Brecciated Quartz* (B), many of which attain to great size and form the crests, and in some cases the mass of very considerable hill ridges. *Pegmatite veins* (C), mostly of small size, are not uncommon, but require but little notice. *Epidote-granite veins* (D) in which epidote in its pistacitic variety takes the place of mica are also not uncommon, but with a few exceptions to be mentioned further on, they are very small and of little interest.

A. The Trap-dykes.

Prevalence of dioritic dykes.

The number of these occurring within the Archæan area is large and many of them are of very considerable size and length and form marked features in the landscape in many places. To the unaided eye they appear to be

mostly composed of a hornblendic diorite, but in some few cases the material composing them was submitted to microscopic examination by my colleague Mr. Philip Lake and found to be mainly augitic instead of hornblendic. It is clear that slices of the rock of all the great dykes deserve examination to determine their composition accurately, but this is a task I have been unable to accomplish from want of time and skill in preparing sections, and no petrographical assistance has been procurable from the Survey Office in Calcutta. The establishment of a special petrological branch in connection with the Survey is a very great desideratum, and must be established soon if the Department is to maintain its position as a scientific one and not to degenerate into a mere mining record office—a fate which now seems to be in store for it at no distant date.

Grouping of dykes by their courses.

If the dykes be grouped according to the direction in which they run, 14 groups will have to be established which groups, however, will be of very unequal importance numerically. The courses of few of the dykes agree exactly with any of the points of the compass and not many are truly parallel to each other, so the groups can only be formed by including in them dykes running in approximately similar directions, each dyke therefore must have its course lying within 5° 37′ 30″ of the point forming its group index.

Distribution of the dykes.

The 260 dykes met with in the several areas, into which the Archæan portion of the district has been divided for convenience of description (see p. 27)—are unequally scattered about, being numerous in some parts and but sparsely distributed in others. On the whole, the Bellary district can boast a fair number of dykes, but it does not approach in richness in these intrusive rocks the tract lying eastward of it from the Tungabhadra southward and including the crystalline areas in Karnul, Anantapur, North Arcot and North-Eastern Mysore in which the intrusion has taken place on a most extraordinary scale both for the size and number of dykes.

In order of the number of dykes belonging to them, the 14 systems just referred to stand as follows :—

1.	W. N. W.	to	E. S. E.	45	dykes.
2.	N. W.	"	S. E.	44	"
3.	N. W. by W.	"	S. E. by E.	30	"
4.	W. by N.	"	S. by E.	30	"
5.	W. S. W.	"	E. N. E.	21	"
6.	W.	"	E.	20	"
7.	W. by S.	"	E. by N.	20	"
8.	N. N. W.	"	S. S. E.	15	"
9.	S. W. by W.	"	N. E. by E.	11	"
10.	S. W.	"	N. E.	10	"
11.	N. by W.	"	S. by E.	6	"
12.	N. W. by N.	"	S. W. by S.	5	"
13.	S. W. by S.	"	N. E. by N.	2	"
14.	S. by W.	"	N. by E.	1	"

Of the dykes belonging to the first system (W. N. W. to E. S. E.) by far the larger number occur in the north-eastern part of the district; and the remainder mostly in the south-western part. Of the second system (N. W. to S. E.) a third part occurs in the westernmost Archæan area and another third in the west central part. In the case of the third system the majority of the dykes are found in the central and eastern part of the district. In the case of the remaining systems the majority of the dykes lie in the western half of the district. In point of size the most important dykes belong to the following 7 directional groups :—

N. W. by W. Group	1. The Avinmadagu dyke[1]	Raidrug area.
	2. The Annampur dyke	
	3. The Waddarhalli south dyke	Hospet area.
	4. " " north dyke	
	5. The Kapgal dyke	Bellary area.
	6. The Adoni dyke	Adoni area.
N. W. Group.	1. The Harapanahalli dyke	Harapanahalli area.
	2. The Uchingi Drug dyke	
	3. The Murvani dyke	Adoni area.
N. by W. Group	1. The Kailasa Konda dyke	Rai Drug area.
	2. The Venkataper E. dyke	Hospet area.
W. by N. Group	1. The Kamalapur N. dyke	Hospet area.
	2. " " S. "	
W. S. W. Group	1. The Tambrahalli dyke	Kudligi area.

[1] The Avinmadagu and Waddarhalli south dyke are the eastern and western extensions respectively of the great Joga dyke which traverses the Joga-Sultanpur tract of the Sandur and Copper Mountain Dharwar area.

In the Sandur area. Golla-Linganahalli dyke.

At the extreme south end of the Sandur synclinal a large dyke shows cutting through the basement beds of the Dharwars locally, and running up north-westward past Golla-Linganahalli and disappearing finally in the basement trap-flow a little to the east of Tonashagiri village. No contacts were to be seen here. To the southward of the extreme end of the synclinal, the great dyke trends south-east and crosses the Rampur spur of Mysore territory (over which I did not follow it up). It is possibly the extension of the great Kailasa Konda dyke west of Raya Drug which runs down south by east to the Haggari river which it crosses, and may be followed by the eye for many miles further south. If the two dykes are really continuous, they measure over 38 miles in length, and are of great size. The dykes rise in many high blocky crests of jet black colour, and are very conspicuous.

The Copper Mountain dyke.

Proceeding north-eastward from Golla-Linganahalli to the Copper Mountain synclinal, a large dyke is found to the north-west of the Sugadevibetta peak which runs in a south-west by west direction. Its eastern end descends the northern spur of the peak; and trending to east by south, crosses the Bellary-Bangalore road near Halakundi, and disappears under the cotton soil a couple of hundred yards west of Mincheri. The dyke at this point has diverged northward just outside the boundary of the Dharwar area; but about a mile further east by south what appears to be a continuation of it rises again and forms a high well-marked outcrop which trends south-east by east, re-enters the Dharwar area in the Mincheri hills, and continues in it for nearly a mile and a half and then dies down at the south-eastern extremity of the Copper Mountain synclinal, and is finally lost sight of under the cotton-soil plain. The dyke consists of black diorite (?), and measures some 13 miles in length along its curve.

Great dyke west of Kudatani.

The only other remarkable dyke in the Copper Mountain band is a very large and broad but ill-defined one lying a mile and a half west of Kudatani, and about the same distance east of the Budikanama Ghat. The dyke

shows as a band of large detached shapeless blocks of black diorite (?) which form no crest, but lie about as if part of a flow, for which it would certainly be taken, but that it cuts across the schists diagonally in a north-west by north direction. It shows for a distance of four miles and its course is parallel with that of a large and conspicuous dyke lying east of Kuditani and its apparent extension four miles further to the north-east,— near Timapur.

The Kapgal dyke.

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extent to furnish material for inverts and road revetments near its eastern end. It is the very toughest rock I ever tried to break, but the felspar has been weathered to a considerable depth nevertheless. Two other small patches of similar trap occur about a mile to the north of this dyke. A very small protrusion of similar blotchy trap is to be seen immediately north of Chaganur on the left bank of the Haggari. It looks very much like an extension of the Permadevanhalli dyke, but if it be so the course of the dyke has made a great trend to the north-west. No other shows of similar trap are known to me anywhere else.

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A. The Trap-dykes.

Prevalence of dioritic dykes.

The number of these occurring within the Archæan area is large and many of them are of very considerable size and length and form marked features in the landscape in many places. To the unaided eye they appear to be

Their dimensions.

In point of thickness and of the height of the ridges they form, they exceed the average trap dykes considerably, but in comparative length they are much inferior to them.

Their age.

They are probably all older than the great dyke series, but in only one single case was a contact between them met with, and in this case the trap dyke had unquestionably cut through the quartz-run, and is now seen to include numerous fragments of it. This is to be seen in the second great quartz-run north-north-east of Harappanahalli above (*vide* above, page 168).

Their number and grouping.

In all 84 of these quartz-runs were mapped, and may be referred roughly to 14 groups, which are however simply directional and in no way geographical.

Accessory minerals wanting.

The almost entire absence of accessory minerals from the quartz-runs is very remarkable, and in only two cases were any indications of an included metallic mineral observed. This was in both cases copper in the form of green carbonate. Inclusions of small pink felspar crystals were also observed in a solitary case, and in the same run in which one of the two copper shows was noted. This will be referred to again further on (page 175).

Occurrence of copper, north of Haroppanahalli.

The other case in which copper carbonate was seen is that of an important run about a mile north-north-west of Harappanahalli (Hurpunhully), which place is quite a centre for great quartz-runs. In this case the carbonate occurs in the forms of films, often of extreme thinness, or small veinlets, coating many joint planes and lining innumerable cracks in the veinstone. The ore is an earthy-looking malachite and old workings for it remain, and will be referred to in the chapter on Economic Geology (page 197).

It is this same run which is cut by a great trap dyke as described above (page 168). No connection seems to exist between the

disruption of the run by the diorite dyke and the occurrence of the malachite in the run.

A smooth ridge.

As mentioned above, the quartz-runs have, as a general rule, very rocky and blocky crests, but an exception to this rule occurs in a great run about 1½ mile north-north-west of Harappanahalli, in which the dirty brownish quartz is so much cut up by excessive jointing on a very small scale that it breaks up into small fragments, and from a little distance presents a strikingly smooth character, such as was noted in no other quartz-run.

Excessive jointing.

These quartz-runs are, as a rule, far more cut up by shrinkage joints than any other crystalline rock, more so even than the finest grained, almost glassy trap rocks, which are seen occasionally in small veins branching from the great dykes.

Unusually white quartz.

A very unusually pure white run of brecciated quartz is to be seen in the hilly tract about 1½ mile south-westward of the south end of the great tank at Harappanahalli.

The great Harappanahalli run.

The great Harappanahalli run which is longest of all in the district, forms several low hills in the western part of its course, which measures 14 miles in all, encircles the north side of the town with a great steep "vallum" as it were, across which there are two gaps, and to the east of the more easterly of the two gaps rises into a knot of hills between 300 and 400 feet high, and then gradually sinks down into the plain about 3 miles east of the town. These hills are not rocky except at their crest, but they are so stony on their flanks as to be almost comparable to screes and to be exceedingly rough to climb. In colour they are very pale reddish fawn passing into cream, which may be regarded as the typical colour shown by the great majority of the runs generally, and especially by those of the Harappanahalli Archæan band.

Kanchkerra run.

In the case of the great run north of Kanchkerra tank, 10 miles south of Harappanahalli, the western part of the run is of the pale reddish fawn colour, but in the eastern half semi-diaphanous sea-green of the most delicate tint appears. Both varieties form very handsome rocks.

Nellapur run.

A great show of sea-green colour mottled with brown, and forming a very typical brecciated rock, is to be seen on the crest of the great Nellapur run, which forms a considerable hill west of the village and 4 miles east of Kamalapur in Hospet taluq.

Dark coloured runs, Jitnakatti hill.

Very brown runs are those forming the Jitnakatti hill, 6 miles south-south-west of Harappanahalli. Similar in brown colour but still darker in tint is the rock forming the very bold and steeply scarped run known as the Tellamatti hill, 5 miles south-west of Bellary, and forming a very conspicuous object in the landscape as seen from the Bellary Fort hill.

Hatti Bellagal run.

A great run of very white colour rises very conspicuously out of the great cotton soil plain of the Alur taluq and forms the pure white crest of the Hatti Bellagal (white rock) with its vertical scarps standing high over the flanks of the hill. Apparent extensions of this great run are the great white crests of the Billihal and Mudal Maggi (Moodal Maggy) hills, 4 and 13 miles, respectively, to the north-westward.

Siddapan Konda run.

Lastly, attention is due to the greatest but not the longest of all the quartz runs, the apparently triple one, which crests the Siddapan Konda in the north-western part of Alur taluq. This great quartz-crest extends for nearly 5 miles west by north from Siddapan Konda Trigonometrical station, to close upon the the bank of Haggari river at Kanchagar Bellagal. The ridge cannot be much less than 800 or 900 feet above the surrounding country.

It rises through the rather gneissic country rock, but unfortunately no satisfactory contact is seen, the country rock being in-

tensely decomposed to a great depth. The quartz at the west end of the great ridge is much whiter and purer than at the foot of Siddapan Konda, where it is so impure as not to be easily distinguished from the rotten country rock. Eastward of Siddapan Konda the ridge falls off rapidly and is cut through by a small stream flowing northward. A mile further eastward yet, the three parallel runs seen at the foot of Siddapan Konda[1] rise again distinctly, but do not attain to any great elevation, probably not to 100 feet above the surrounding country. In the highest tor standing on the top of the main ridge the quartz shows slight stains of copper green; and in the quartz close by are enclosed numerous small crystals of pink felspar (see page 168). The mass of the quartz has in parts assumed a cherty look, which seems to be owing to the presence of very minute quantities of very finely divided chlorite which pervades the quartz like a cloud.

Other important runs south of Harappanahalli.

None of the other runs offer any points of special interest, but there are several that may be noted for their great size either in length or height, or both. Among these are the two great runs forming the southern side of the fan-shaped group of runs which radiate westward from a point some 3 miles east-south-east of Harappanahalli town. The more southerly of the two has a course some 7 miles long and forms considerable ridges in its eastern and western parts, the central part being much lower. Another group of large and conspicuous runs occurs in the southern part of the Harappanahalli taluq between Teligi (Tellyghee) and Uchingi drug.

Ujinni and Nimbalgiri runs.

Two high runs form the bold rocky crests of the Ujinni (Oojinny) and Nimbalgiri hills, both of which rise some 400 feet above the surrounding country, reaching respectively, the heights of 2,370 feet and 2,650 feet above sea level. These occur quite in the south of the Kudligi taluq, while to the north of Kudligi town the great run which commences in the Niddagurti hill forms a consider-

Niddagurti hill run.

[1] Siddapan Konda, a very bold peak, rising 2,151 feet above sea-level, is the highest point in the district east of the Haggari river.

able ridge which stretches north-west by west for a distance of 9 miles.

Great run south of Yemmiganur.

In the extreme north-east of the district is another great run which forms the boundary for some 3 miles between the Bellary and Kurnool districts about 3 miles to the south of the small town of Yemmiganur (Yemmaganoor). It forms a considerable ridge in its eastern part which is very rocky and bare, and from its light colour a widely conspicuous object.

C. Pegmatite veins.

Veins of pegmatite of large size were not met with in the Bellary archæan tracts, but small ones a few inches or less in thickness are common enough. As a rule they are very irregular in their thickness, alternating from mere strings to thick node-like expansions. Their length, too, was in most cases but small, but in many instances it could not be determined because of insufficient exposure. They present the character of veins of segregation rather than of true irruption. In colour they are mostly pale, the orthoclase being, as a rule, of a very light flesh-colour. In no case that came under my notice was the "graphic" structure distinctly visible, as it is in the pegmatites of many other archæan tracts in the Peninsula.

D. Epidote-granite veins.

Small veins of epidote-granite a few inches in diameter are common enough in the epidotic tracts, but large dykes or veins large enough to be worth indication on the map are few and far between.

Great vein at Molagavalli.

The most remarkable of these is a very large vein noted by Mr. Lake near Molagavalli, a large village lying some 7 miles east-south-east of Alur, in the middle of one of the largest unbroken spreads of regur in the peninsula. The granitic rocks in the south-eastern corner of the Alur taluq are remarkably rich in epidotic intrusions (segregations?), and form one

of the specially epidotic tracts of the peninsula,—a tract which extends into the adjoining Karnul district to the westward of Maddikerra railway station and the Guntakal junction. This great vein, which is to a great extent obscured by the overlying regur, must measure many yards across.

A good-sized vein several feet in diameter is exposed for a few yards distance in a rain gully to the eastward of the white quartz-run north of Ram Drug hill. It shows a sharp clean-cut line of contact with the country rock (which is a hornblendic granite), in which neither side shows any alteration.

Away some 20 miles to the north-west of this great epidote granite vein on the high ground between Hira Harrivana (Heery Hurravana) and Gejjahalli are at least two considerable groups of good-sized epidote granite veins traversing the felspatho-hornblendic granite there forming the country rock. The rock, though not in sufficiently large masses to be of appreciable value for decorative purposes, is one of great beauty, the rich green of the pistacite (epidote) contrasting admirably with the warm pink or red of the felspathic constituent.

E. Enstatite rocks, veins and necks.

Dykes and necks of enstatite rock are uncommon throughout the south of India, and only a few instances of its occurrence have been noted, of which three lie within the limits of Bellary District. They are of special interest on account of their rarity.

Near Alur.

The most striking of these three examples is the one occurring a mile to the south-west by west of Alur taluq town. It is a big mass of intensely black rock rising out of the cotton soil, and is about ½ mile along its major axis, and approximates to an ellipse in plan.

Mr. Lake regarded this rock as a hornblendic picrite.

Dyke on Malleshwaram gudda.

A small band or dyke-like intrusion of enstatite rocks occurs rather more than 6 miles to the north-west by west of the Alur neck on the western side of the fine hill known as Malleshwaramgudda. Its relation to the general

mass of granitoid rock surrounding it could not be seen owing to a great débris-talus and to jungle growth.

Near Harappanahalli.

The third example of enstatite met with was found close to the Yallapur tank, 4 miles north-west of Harappanahalli. The rock is of dark grey colour and exceedingly coarse grain. Here again no contact is seen with the country rock which is a rather remarkable variety of finely banded "Augen Gneiss."

CHAPTER VII.

HIGH LEVEL LATERITOID TALUS TERRACES.

Along the central part of the southern flank of the Kumâraswami plateau occur two distinct terraces, of very considerable interest, which abut against the main slope at about one-third of its height above the adjoining low country. The surfaces of the two terraces are very generally uniform, and have gentle slopes southward down to their sharp-cut and generally rather scarped southern edges. Along their northern edges close in to the base of the flank of the plateau the slopes of the surface are for a short distance much greater owing apparently to the continuing accumulation of talus.

The surface of these terraces is formed by a thick hæmatitic talus breccia, increasing in coarseness as the flank of the plateau is approached. The breccia has been greatly lateritised and shows much vermiculate tubulation as well as much pisolitic structure. As far as can be judged by the sections formed in rain gullies near the edge of the terraces, the brecciated talus mass is about 20 feet or rather more in thickness, and rests along its northern side on the basement beds of the Dharwar system and along its southern side on greatly decomposed felspathic granite. The edge of the scarp is almost everywhere greatly obscured by a local talus of big lateritoid blocks. Where the surface is bare of vegetation the contrast between the deep red brown of the hæmatitic breccia and the pale decomposing granite is very great and conspicuous.

Thickness of the talus breccia.

Extent of the terraces.

The extent of these talus-breccia terraces is considerable, the western terrace measuring about a mile in its greatest width, and nearly two miles in length along its southern edge, but only about a mile along its contact with the base of the plateau scarp. In plan it is rudely lozenge-shaped with the longer axis lying south-west by west to north-east by east. The eastern plateau is about 2 miles long and ¾ of a mile wide near its western end, and narrows steadily as followed eastward.

Former extent of the formation.

The terraces were formerly of much greater extent, a fact proved by the occurrence of two well-marked little outliers on the tops of two small hills, one, half a mile south of the eastern extremity of the eastern terrace, and the second one nearly a mile and a half further east. They rest on decomposed granite similar to that underlying the main terraces. Since the separation of these outlying talus breccia patches from the main terrace, the face of the country has undergone great erosion, the granite surface having been cut into and removed over a considerable area to depths of from 100 to nearly 300 feet. The surface of the granite tract south of the Kumáraswami plateau must average between 2,300 and 2,400 feet above sea-level according to the heights ascertained by the Mysore Topographical Survey.

No clue to the geological age of these remarkable talus terraces could be obtained, no trace of any organism having been met with in the hæmatitic breccia forming them. The great amount of erosion the country has undergone since their formation shows that they cannot with probability be classed as of recent origin. Two other examples of the kind, but of much smaller area, were noted elsewere—the one on the northern slope of the Kumáraswami plateau overlooking the village of Nandiballi, the other on the eastern edge of the plateau overlooking the abandoned village of Bussuanooty. The first of these terraces stands out from the scarp of the plateau very much like a bracket, its surface being approximately level and its northern edge very abruptly scarped.

Other talus breccias.

CHAPTER VIII.

Alluvial Deposits.

The alluvia formed by the principal rivers draining the Bellary District are of limited proportions when compared with the size of the rivers themselves, a fact that must be attributed to the rapid fall of the river beds in most parts. The alluvia are not shown to any extent on the map accompanying this memoir, for in many places they are so much mixed up with protruding masses of the more important Archæan and Transition rocks, that it would be impossible to show both clearly except on a much larger-scaled map; and in many other places the alluvia are so much covered up by subaerial deposits that it is impossible to trace their boundaries.

High-level shingle beds. At Makrabbi.

Except in the case of the Tungabhadra the alluvia do not attain to any notable thickness. In this case, however, there is abundant evidence that the river at some not very remote period occupied a very much larger channel than its present one. The evidence of this consists in the existence at many places along its banks of well-marked and important beds of coarse but well-rolled shingle consisting chiefly of quartz pebbles, and showing generally a pale cinnamon-brown colour from the predominance of the quartz pebbles. Gneissic and granitic pebbles come next in quantity, while quartzite and jasper pebbles are less common. Trap pebbles are rather rare. The greatest development of these high-level shingle beds is met with along the right bank of the river between the Mysore boundary north of Harihar (Harryhur) and the barrier formed at the northern end of the Sandur Hills. The shingle beds attain their greatest height over the present bed of the river at Makrabbi in Haddagulli taluq, where they form a regular plateau several hundred acres in extent and of conspicuously reddish colour. The surface of the plateau at Makrabbi village must be close upon 100 feet if not more above the general level of the Tungabhadra in the reach immediately to the north. Higher up the river much high-level shingle of the

typical cinnamon brown colour occurs along the western part of the Nittur reach and to the south-south-west of Karabbagaddi fort. At the former locality I obtained a palæolithic quartzite implement of fairly good make from the surface of the gravels.

Shingle beds near Holal.

Another notable show of these high-level gravels occurs on the right bank of the river west-south-west of Holal. The gravels are much hidden by cotton soil which covers their irregular surface. In places where the gravels with the overlying cotton soil form slopes rising eastward, and the former show protrusions through the latter, small fans of the cinnamon-coloured pebbles have been locally spread over the black soil. The gravel beds in this neighbourhood rest directly on the upturned edges of the drab Dharwar schists which occur so largely all over the Holal plain.

Shingle bed at Hampasagra.

Many patches of the high-level shingle occur at irregular intervals down stream along the river reaches between the Honur Gorge and the village of Hampasagra where the river has cut a steep cliff in which, and in the knoll to the south (on which the travellers' bungalow is perched), the nature of the gravels is well seen. They are also conspicuous at Bassarkod, Bamingola and Mutakur, localities lying respectively 4, 6, and 10 miles further down the right bank.

Shingle beds at Wodagola.

Below the barrier of Dharwar rocks over the river at the north end of the Sandur hills the shingle beds are less frequently seen, and as a rule of much less extent. An exception to this rule is formed by the Wodagola gravel beds on the northern edge of the Pennér Haggari Dharwar band. Another exception is a shingle bank at Bagawadi, 4 miles above the junction of the Tungabhadra and Haggari.

At Bagawadi.

At Nagaladinni.

The most easterly shingle formation belonging to the high-level series that is deserving of special mention is that capping or rather forming the ridge of high ground about a mile south of Nagaladinni (Naguldinny) in the

north-eastern corner of Adoni taluq. Its surface is largely mixed with and much concealed by cotton soil.

Talus and Torrent fans.

To the alluvial formations must be reckoned the remarkable fan-like deposits of coarse and fine débris brought down and spread out over the face of the country, but most markedly along the northern flanks of the Copper Mountain ridge, where they form an almost continuous fringe. They are more especially well developed along the northern base of Sugammadevibetta, the Copper Mountain itself. They are well seen from many points to the north of the railway.

Their limits.

Their northern limit and their relation to the existing streams draining the various ravines opening from the main ridge is very obvious to every intelligent observer. It is easy to see how they have been formed by the streams to which they owe their existence. These streams have carried quantities of débris, chiefly sub-angular in shape, in flood times, and spread them over the open country just outside of the ravines. The deposits thus formed compelled the streams to shift their courses some distance laterally on one side or the other, as the case might be, each time that they descended laden with fresh supplies of débris. In time they had blocked up the mouth of the ravines giving them exit from the range. When thus dammed back, they either flowed over the dams they had formed and raised them yet more over their former level and extended the deposit into fan-shaped accummulations so-called "cones of dejection," or else they burst through their former deposits and cut channels through them and recommenced forming other fans or cones, generally on a smaller scale at lower levels further out in the plain.

Local rain-fans.

By the action of local torrents suddenly created by intensely heavy sporadic rain storms other fans have been formed and the detritus of the old hill-foot fans, and of the ordinary talus accummulations distant from any ravine stream, have been moved away far from the hills they were originally derived from.

No one who has resided long in India and has watched atmospheric phenomena with any degree of care can have failed to observe such local storms of great violence, and if caught in one of them, the experience then gained will lead to ready and perfect comprehension of the remarkable extent to which local debacles modify the distribution of detrital matter far and wide over the face of the country.

To the action of such local storms we may, I think, safely attribute the scattering over the surface of the country of isolated beds of gravel whose existence cannot be attributed to the action of the local rivers and nullahs. Examples of such are the cinnamon-coloured shingles occurring to the north-west and east of Kapgal in the Bellary taluq. These quartzose (? quartzite or vein quartz) shingles lie on the surface of the cotton soil at heights never attained by the flood waters of the streams now draining the country. Other examples of the kind are the shingle beds composed of Dharwar débris to be seen to the north-west of Soma Samudra and Yerra Inglagy.

Present action of the rivers.

At the present time the rivers in Bellary district deposit but very little débris. They seem rather to be entirely engaged in cutting their channels deeper. The only depositing that now takes place happens in the rare event of floods so high that they top the present banks and leave a sediment behind, but as such high floods occur but rarely and are of short duration, the amount of deposit made is very slight and consists as a rule of a reddish slime (which dries into a pale reddish loam) or else of fine reddish sand. Within the existing beds the action of the rivers is mostly a purely erosive one. Sand-banks and mud-banks do occasionally form of a height sufficient to get covered with grass and tamarisk bushes, but they do not acquire sufficient elevation to become true islands standing well over ordinary flood levels and offering surfaces suitable for habitation and cultivation by man.

Case of recent high-level deposition.

One interesting example of high-level deposition within comparatively recent times was noted on the north bank opposite to Hampasagara, where a thin bank of reddish sand loam from 3 to 4 feet thick

had been deposited over a cemetery of late neolithic or early iron age. The graves had been only just covered over by the deposit, and it was already being eroded largely by the local rainfall at the eastern end of the cemetery, and some of the graves re-exposed and partly worn away. There was nothing to show the exact date when the loam deposit was piled over the prehistoric graves, but it was probably at some very remote period, speaking historically, for their surfaces had been but very little disturbed before they were covered up.

The graves stand upon a level tract lying about a quarter mile north of the high cliffy bank of the river, but a rather lower level than the present top of the bank, which is the red loamy bed covering the old cemetery. In and under the loam bed at the edge of the cliff occurs an immense quantity of antique pottery, mostly broken, but occasionally entire, and showing by its domestic character that the place is the site of an ancient settlement, and was probably the habitation of the old people that had buried their relations in the adjacent cemetery.

The alluvial cliff, about half a mile west of the old pottery-yielding site, showed the following section:—

3. Red sandy loam with prehistoric pottery in fragments . . . . . 6" to 3'
2. Drab sandy clay with kankar in very variable proportions . . . 6" to 8'
1. Blackish sandy clay (washed up cotton soil) with sub-fossil shells, the whole deposit rather kankarized . . 15' to 20'

The sub-fossil shells consisted of corbicula, a medium-sized unio with very wrinkled umbo, and very numerous specimens of a large paludina. No traces of fossil bones rewarded a long and careful search, despite the very promising look of the formation. On the south or British bank of the river the alluvial section was obscure, and the fossiliferous clay could not be traced, nor the position of the high-level shingle bed abovementioned (page 181) relatively to it determined.

Rarity of fossil remains in the alluvia.

A long cliff section of reddish loam, from 30 to 40 feet thick, occurs in the reach of the river immediately north of Honur (3 miles north-west of Huvina Haddagalli). I searched this loam cliff and many others at other places up and down the Tungabhadra with great care for fossil bones, but was everywhere unsuccessful.

No good sections were noted anywhere in the banks of the Haggari, which are generally low or else not scarped into sections fit for study, and the same was the case with regard to the alluvium of the Chinna Haggari in the Kudligi and Haddagulli taluqs.

Crocodilian and other bones in the Avinamadugu.

In a small cliff section in the Avinamadugu or Sultanpur nullah, about half a mile south of where the Bellary Dharwar high road crosses it, a small number of fossil vertebrate bones and numerous fossil freshwater shells were found by me. Among the bones was a large crocodilian vertebra, now in the Survey Museum, but not specifically determined as yet. The fossil shells are all of living species now occurring in that quarter. The genera represented were Unio, Corbicula, Melania, Paludina, Lymnæa, Planorbis, all of living species.

They are deposited in regular laminæ in the loam which is otherwise unstratified.

Red alluvium of the Nari Halla.

A great show of reddish loam occurs along the banks of the Nari Halla (Sandur river). It owes its red colour to the great quantity of ferruginous matter brought down from the Sandur hills. The numerous bright red jasper pebbles which make the bed of the Tungabhadra quite gay at the ford at Bagewari, in Bellary taluq, appear all to have been carried down the Nari Halla.

Cementation of gravels.

A phenomenon of some interest, of which various examples are to be seen in the district, is the cementation of gravel beds by deposition of calcareous matter in them as the flood waters dry up. The beds thus solidified are of the most varied character, from mere grits up to the coarsest boulder gravel. The finest examples of such cementa-

tion occur in the banks and bed of the Nari Halla between Virapur (an abandoned village), ½ a mile south of the Ettinahatti (Yettemhutty) travellers' bungalow, and Tallur, 3 miles to the north. Similar cemented beds are to be seen, though on a smaller scale, in many of the nullahs draining the different tracts of Dharwar rocks.

The calcareous matter by which these shingles and other deposits are cemented appears to have been introduced into them by the flood-waters of the rivers and streams in whose beds and banks they occur and to have been precipitated as the waters retreated; the formations are therefore preferably regarded as of aqueous origin, but cases of cementation occur also on a small scale which must be regarded as of distinctly subærial character.

CHAPTER IX.

SUBAERIAL FORMATIONS AND SOILS.

The formations to be considered first in this chapter are of small importance, and with one exception of very limited extent. The exception is formed by the purely æolian formations which in Bellary district consist only of river-side dunes or sand-hills raised by the action of wind on the broad sandy beds of some of the rivers during the many months when the surface is dry. The other subærial formations are kankar deposits or calcareous tufas and local hæmatitic breccias formed by quasi-lateritic cementation of the weathered surfaces of many of the great hæmatite beds already described.

Blown sands of the Haggari valley.

The greatest show of blown sands occurs along the right bank of the Haggari river from the village of Honur downward to Marlamaddaki, a distance of over 40 miles. It is only on the right bank of the river that the dunes are formed by the westerly winds which prevail during the driest months of the year as well as during the south-west monsoon. Formerly the sands advanced without let or hindrance, and did serious injury in some villages by covering up considerable tracts

of fertile soil, and in two cases at least overwhelming the villages themselves. This was at Jiraganur, about 3 miles below the Haggari Railway bridge, where the ruined village temple still protrudes from out of the sand and at Bodurti, a village 8 miles from Honur mentioned by Newbold as having been totally buried about 13 or 14 years before his visit to Honur in 1839. It was completely covered by the sand drift with the exception of the tops of the walls. Of late years the advance of the sands has been greatly checked at various points along the river by plantations of casuarina trees.

Newbold[1] states that the season when the sands advance most is during the months of June, July and August, when the south-west monsoon is at its highest. He is very probably right, but I can from personal observation add that the westerly wind is very busy moving the sands eastward already much earlier in the year.

The line of dunes is not an unbroken one in the lower third of its length from the Moké ford downwards. The greatest width of the sands is about ¾ of a mile as at the buried village of Jiraganur, and east of the Moké ford and again in the patch N. W. of old Guliem (Gooleum), elsewhere the width may average about ½ of a mile. The dunes rarely attain to an elevation of 20 feet, and none exceed 30 feet as far as my observation went.

Blown sands of the Tungabhadra valley.

The only other patch of blown sands worth noting is on the right bank of the Tungabhadra between it and the village of Holal in Hadagalli taluq. It is of no great height, but is remarkable for the markedly reddish tinge of its colour, which reminds one somewhat of the impure teri sands to the south of Ramnád, where they begin to mix with the whiter sands of the coast line of dunes. The cause of this unusually red tinge for these river sand-dunes is not obvious.

Small wreaths of blown sand, too small in size to be termed dunes, occur here and there scattered about on waste sandy tracts on the red soil area of Kudligi taluq.

[1] Notice of the River-dunes on the banks of the Hogri and Pennaur, Madras Jl. Lit. and Sci. Vol. IX, p. 309.

Formations of calcareous tufa or kankar are of common occurrence, especially on hornblendic rocks, but are mostly of too limited extent to be worth noticing. An exceptionally large and massive deposit of the kind unconnected with any existing stream is to be seen at Waddarhalli, a small village 6 miles E. by S. of Hospet.

Wadderhalli massive kankar formation.

Of true travertine formations due to the deposition of calcareous matter in stream beds two good examples were noted; one in the bed of the stream which breaks through the Dharwar conglomerate beds in the spur of Jambanath Konda described at page 106 and forms a well marked "water slide." The travertine deposit accumulated on the face of the slide in great stalactitic masses which formed a shallow basin over the edge of which there must at one time have been a waterfall of considerable beauty in the rainy season. By some great flood the basin was burst and large masses of the travertine lie about in confusion at foot of the slide. The travertine is of greyish drab to deep velvety greenish brown in colour and banded in parts. If large and solid enough masses were procurable, which they are not, they could be worked into a very handsome "Oriental Alabaster." The general mass, however, is not solid throughout, many cavities of various sizes existing between the tubular stalactitic portions. The tenacity of the masses is very unequal—some broke so easily as to deserve to be called brittle, and against one I shivered the handle of my hammer in trying to break it up in search of impressions of leaves of which I found a number but could not secure any good ones. Such as were recognizable were all of leaves of trees now growing on the adjacent hills, specially of a kind of fig with a very thick leathery leaf. In some of the masses were long cylindrical holes as if the calcareous mass had been deposited round stems of a bamboo which had subsequently decayed away.

The "water slide" Travertine deposit.

From the general look of the débris of the old basin its disruption appeared to be of rather recent occurrence, and may very

likely have been one of the consequences of the great rain-storm of 1851, which caused great mischief throughout the district by the heavy floods it gave rise to.

Golla Linganaha waterfall.

The other travertine deposit met with is in the gorge by which the drainage of the southernmost end of the Sandur hills falls into the Rampur nala, a little distance south of Golla Linganahalli. The travertine mass forms a small vertical cliff across the bed of the torrent which in wet weather must make a pretty waterfall here.

Hæmatite surface breccias.

The hæmatite breccias above referred to are very numerous on the bassett edges of many of the great hæmatite beds of the Dharwar system. They are formed simply by the cementation of angular débris of the hæmatite beds by a local ferruginous mud formed by the atmospheric agencies continuously at work. Examples of such breccias are extremely common but none were noted large enough to be mapped: indeed very few of them cover an area of more than a few square yards. They not unfrequently assume a pseudo-lateritic appearance where the débris had been much comminuted. One of the best if not the very best example of a highly lateritized breccia is that covering the small summit plateau of the Copper Mountain.

Soils.

The soils of the Bellary district are chiefly referable to the two great divisions of the red and the black, and their distribution is largely affected by the presence or absence of hilly or deeply broken ground. Where the ground is hilly, as in the western parts of the district, there the cotton soil forms spreads only in the central parts of the flats, but wherever the ground rises steeply it disappears as a rule with but very few exceptions. Among the hilly and rocky tracts black soil hardly ever occurs, the rocks there being almost always covered or surrounded by red soils of varying richness in their percentage of iron oxides. Even in the middle of the greatest spreads of cotton soil wherever a large rock or hill stands up, it will, in ninety-nine cases in a hundred be found surrounded by a large or small talus of red soil,

the lower part of which underlies the surrounding cotton soil, while the upper part (especially where the hill consists of an easily weathered rock) may be seen to extend as a rain wash over the surface of black soil.

Cotton soil.

The cotton soil or regur of Bellary district is a very typical variety of this often described old forest humus, and there is nothing specially new to say about it. The greatest spreads of it occur along the valley of the Haggari in the Rayadrug, Bellary and Alur taluqs. The Alur spread extends north and covers a great part of the western half of the Adoni taluq, while in the north-eastern part of the Adoni taluq there is a broad spread of the black soil along the south bank of the Tungabhadra. In the western part of the district there are several smaller but yet important spreads in the south-western and south-eastern and north-eastern parts of Haddagalli taluq. In Kudligi taluq the regur spreads are met with mainly along the valley of the Chinna Haggari river.

A fair average of the thickness of the black soil in the principal spreads is 4 feet, but much greater thicknesses are seen locally. The soils derived from the direct decomposition of the granitic rocks is everywhere a reddish loam more or less sandy according to the larger or smaller percentage of quartz the original rock had contained. White salty soils occur commonly enough along swampy reaches of sluggish streams, but are nowhere sufficiently developed to demand special notice.

The soils derived from the decay of the different members of the Dharwar system are in nearly every case loams of light quality and more or less ferruginous according to their proximity to the great hæmatite beds.

CHAPTER X.

ECONOMIC GEOLOGY.

Excepting in the matter of iron, of which immense quantities occur in the Dharwar rocks of Bellary district, and of excellent building stones, of which an inexhaustible supply is to be found, the district

cannot be regarded as a rich one minerally. In iron ores, however, as the description of the Dharwar rocks in the foregoing pages has abundantly proved, the supply of hæmatites of very variable, but often of very great richness, is practically unlimited, and the country may be regarded as probably the very richest in iron ore in India, and as one of the richest in the world, exceeding in its wealth in iron even the much more famous magnetic iron region of Salem.

The other metallic minerals found in the Bellary country are in order of their importance manganese, gold and copper.

In non-metallic minerals the district is very fairly rich—building stones, as already stated above, are very plentiful, limestones excepted. —Ochres and other pigments occur in abundance locally—Soapstone and potstone, which are in demand for the manufacture of fire-resisting culinary utensils and occasionally of idols and monumental figures, are found in large quantities, while limes and cements and clays for pottery and brick-making are of common occurrence. The localities in which excellent materials for road metalling are to be had for the mere quarrying are simply innumerable.

The minerals and rocks of the district have many of them been worked from times long preceding the earliest that can be reckoned historic, and a brief account of the pre-historic mineral industries will be given in the next Chapter.

a. Iron.—The iron ores of which the district contains such prodigious wealth deserve prominent notice, although they have as yet been but little used. Nothing more need be said here of the position and extent of the great hæmatitic beds of the Dharwar system, as those points have been amply dwelt upon in Chapter V, and are clearly shown in the maps and sections which accompany this Memoir. The magnetic iron deposits of gneissic age are unimportant and will require but little more notice.

Iron-smelting.

The iron-smelting industry of the present time is but small, and is carried on in only a few villages, and principally in the three now to be enumerated—Kamalapur, Kannevihalli, and Shiddagal.

At Kamalapur.

The Kamalapur smelting furnaces work up an ore derived from a spur of the Jambanath Konda, which is crossed by the lowest of the hæmatite bands in that part of the Sandur synclinal. The ore is soft purple hæmatite of very fairly rich quality, and yields an iron which is much prized for the manufacture of the large bowl-shaped boilers extensively used for boiling the cane-juice derived from the extensive sugarcane crops raised along the valley of the Tungabhadra from near Hospet to below Kampli, wherever the river-fed irrigation channels extend to. Most of the Kamalapur iron goes to make such boilers, the locally made iron-plate being much preferred to imported sheet iron.

The cost of a boiler 11 spans in diameter was in 1886 ₹120 and it would with fair treatment last five to six years. The boilers are used till worth patching no longer, and many old ones showing a most extensive series of mendings are to be seen lying about disused near the sugar-growing villages. The old iron is never used again by the natives as far as I could ascertain.

The smelting furnaces were in work when I last visited Kamalapur (in 1886); but I did not witness the operation of hammering the refined blooms into sheets. Several boilers I inspected were very creditable pieces of smith's work.

Kamalapur lies 7 miles north-east by east of Hospet, and close south of the ruins of the famous old Hindu city of Vijayanagar, the capital of the great dynasty of that name.

At Kannevihalli.

The second iron-smelting centre is that of Kannevihalli, a village just outside the Oblagandi Cañon, or pass, the western gorge by which the Narihalla enters the Sandur synclinal. The industry is not an important one, and was not in an active condition at the time of my visits to the neighbourhood.

The soft but rich ore here used is a reddish-purple weathered hæmatite brought down on bullocks' backs from the old iron mine of Adargani, 1½ mile west of the famous Kumaraswami temple on the south-west plateau (see page 121). Kannevihalli village belongs to Sandur State.

Smelting was also occasionally carried on at Mallapur in Kudligi taluq, some 6 miles west by south of Kannevihalli, and had been in earlier times an industry followed in various other villages in that quarter in which it is now extinct.

At Mallapur.

A fairly lively iron-smelting industry was being carried on in 1890 at Shiddagal, a village in Kudligi taluq, 15 miles south by east of the old Adargani iron mine from which the ore is carried down on pack-bullocks. The ore here used was the same as that taken to Kannevihalli, and the quality of the blooms apparently as good as those turned out at Kamalapur; but I did not see any articles manufactured from which to judge of the quality of the out-put.

At Shiddagal.

The blooms made here were carried away by traders and worked up elsewere. Much of the iron must, I should think, be used in making sugar-boilers of the Kamalapur type, for much sugarcane is grown in this region under tanks and in the valley of the Chinna Haggari (or Janagahalla), where irrigated from the river.

Magnetic iron is very sparingly distributed through the Bellary district. I only came upon three outcrops of it, and all of poor character and not worth working in a neigbourhood so rich in fine ores. Of these three the first is on Gudadur hill, 12½ miles N. E. by N. of Bellary; the second crosses the high rounds from Bellary to Kudligi, 4 miles N. E. of the latter place; and the third occurs close to Cooryhutty, 6 miles S. S. E. of Jaramalla Drug, also in Kudligi taluq.

In the second case the magnetic iron occurs in a hornblendic gneiss which forms a narrow band extending 4 miles to the south-east.

Underlying the ore bed at the Adargani mine are some ochreous argillites of rich red colour and also of yellow in many shades which appear to have been worked to some extent for pigments, for which purpose they appear to be admirably adapted.

Earthy red hæmatite as a pigment.

Along the western base of the Ramandrug section of the Sandur hill group a vast quantity of intensely red earthy hæmatite lies scattered thickly over the great talus. This also seems to be a very pure mineral,

and would yield a splendid pigment for the mere trouble of collecting and grinding it. The outcrop of the parent bed is not visible where the ghat road between Ramandrug and Narayan Devar Kerra crosses it.

Similar argillites of delicate cream, pinkish lilac and other tints, are to be seen at various points lying between the different hæmatite beds, and offer material suitable (apparently) for the preparation of pastel pigment in great variety if any demand for such existed in India.

b. Manganese.—The Manganese ores met with in the district are all of the same kind and may be described as an oxide somewhat poorer in oxygen than common dioxide.

The ore was met with in four different localities in sufficient quantity to be worth exploiting, and small traces of it are of common occurrence in the hæmatite beds of the Dharwar series.

Manganese ore near Ramandrug.

The first of the localities occurs on the western slope of the Ramandrug plateau, the north-western section of the Sandur hill group. The schist beds in which the manganese ore occurs in the form of compact earthy-textured, dark grey or black concretionary nodules, lie rather more than half-way down the ghat road which leads to Narayan Devar Kerra. The schists are drab in colour, and the nodules show up distinctly. It would be easy to quarry the nodules along the outcrop of the schists if they prove of sufficient value when the place has been opened up.

Analysis of ore.

A fair specimen of this ore, which was analysed quantitatively in the Survey Laboratory (Calcutta) by Mr. Philip Lake, B.A., was found to have the following composition :—

Insoluble matter and SiO_2	38·96
$Fe_2O_3 + Al_2O_3$	12·82
MnO_2	42·90
CaO	0·78
H_2O (combined)	3·16
H_2O (hygroscopic)	0·67
	99·29

Available O=7·33 per cent. equivalent to 39·86 per cent. of dioxide.

The manganese appears to be in a lower state of oxidation than dioxide, and is probably in the form of *Braunite*, or *Hausmannite*.

Manganese ore south of Kannevihalli

The second locality occurs 2 miles south of Kannevihalli on the western flank of a small spur extending northward from the south-western apex of the curve of the Kumaraswami section of the Sandur hills. The ore which is much blacker in colour and of richer quality than that occurring on the Narayan Devar Kerra ghat, is imbedded as nodules in a greyish soft argillite which is greatly weathered on the surface. The nodules are of all sizes, from that of a small nut up to a child's head. They occur in large numbers, and could easily be quarried along the bare side of the hill and shot down to the foot of the spur whence to be carted on a tram and carried to the nearest railway at very small cost.

The ores are thus of fairly good quality, and will in all probability be of considerable value ere many years have elapsed, especially if iron-making on a large scale should be started to utilize the hæmatites which abound so greatly in Bellary District. The supply available is considerable even without any deep mining.

Manganese ores on the south flank of the Sandur hills.

The two other localities yielding manganese ore occur some 7 and 8 miles, respectively, south-east of the Kannevihalli spur. The manganese nodules are seen exposed on a narrow terrace a little below the edge of the Kamaraswami plateau where crossed by the foot-paths leading from Tonashagiri and Somahalli respectively to Kammatarnou (Combudhurroo) at the eastern end of the plateau. The sections seen do not expose the rock sufficiently to show whether or not the nodules are plentifully distributed through the matrix or only of rare occurrence. If the latter is the case, these two localities would be of no value as sources of the ore, and as it is the nodules of ore observed were poorer in quality than in either the Ramandrug or the Kannevihalli spur localities.

If the maps (Atlas sheet 50 and 1-inch Madras Survey) are to be relied on all four of the manganese localities lie outside the boundary

of the Sandur State, but I did not see any boundary stones on the ground by which to make sure of the exact position of the out-crop.

c. Gold.—This precious metal is at present known only to occur in one rather limited area included in the limits of the Mallapan Betta band of the Dharwar series, where it is occasionally worked by a Jalagar residing at Chiggateru in Harappanahalli taluq, who washes the sands of several small streams flowing from the Jajkal Gudda, a great hill lying about 6 miles east-north-east of Harappanahalli. The gold is in all probability derived from several small reefs of good-looking bluish quartz which occur in the schists forming the country rock in that quarter. In none of the reefs was I able to detect free gold; but the gold washed in my presence was sufficiently large in grain to show that some of the parent rocks must have contained very distinctly visible inclusions of it.

Gold washing near Chiggateru.

The best yield of gold was obtained from the Konganahosur stream, which flows north-east from the north-east flank of the Jajkal Gudda, where, however, no reefs were seen; but a good-sized one lying in the water-parting 1½ mile to the south of the washing place may well have been the source whence the gold was derived. The second best yield was obtained from a small stream west by north of Chiggateru not shown in the map. The third came from a place called Changulu in the valley west of the Jajkal Gudda. Washing in the Maithur stream lying half-way between Chiggateru and the Konganahosur stream yielded a surprisingly poor result in view of the position of the head-waters of the stream. The Konganahosur gold is almost coarse enough for some of the larger particles to deserve the appellation of "pepitas" (cucumber or melon seeds), and the colour in all cases was very good.

In the Konganahosur nullah.

A thoroughly exhaustive prospecting of the reefs which show on the flanks of Jajkal Gudda was advised by me at the time of my examination of this small gold field; but I believe it has not been carried out, so I would again recommend it to be done.

Quartz reefs on the Jajkal Gudda.

The Jalagar, a very fairly intelligent man, informed me that he had tried washing for gold in the streams of the Kunchur band of Dharwar rocks, but without any success. This unsupported evidence is inconclusive, and I would recommend further trials being made at Kalhalli (Cullhully) and in the different streams falling in to the Halla gilwad tank and into the Yerrayball-Muttur nala.

Gold washing in the Kunchur band.

No auriferous locality is known to the natives, Chiggateru excepted, as far as my extensive enquiries went.

d. Copper.—This metal has been found for certain in two widely separated localities, and is reported to have been mined in a third where its alleged occurrence has given the name currently used by Europeans for the most central and conspicuous mountain in the district, the so-called "Copper Mountain" near Bellary.

The two localities, as to which no doubt obtains, are the one near to Harappanahalli in the south-west part of the district; the other, in which mere traces are to be seen, occurs at Hollalgundi in the eastern central part.

In the first and second cases referred to, the ore occurs in the quartz rock forming two of the great quartz-runs so characteristic of the oldest (archæan) crystalline rocks of the Peninsula.

The discovery of copper on the Sugalamma Konda,[1] the Bellary Copper Mountain, is vouched for by no less trustworthy an observer than Captain Newbold, and a legend exists that the metal was mined for by Tippu Sultan when master of the Bellary region. Newbold's account, however, does not describe the locality where he found it with sufficient precision to enable its exact whereabouts to be identified, and I was unable to find it, though I examined the mountain closely and carefully from three sides. On the third occasion, I had the benefit of guides specially deputed by the Tahsildar of Bellary to show me the old mine. They led me to a shallow excavation

Tippu Sultan's Copper mine.

[1] Or Sugadevibetta—the former name is used by the Canarese people, the latter by the Telegu people of the neighbourhood.

(on the south side of the steeply scarped north-east spur) cut into the hæmatite quartzite rock, but there were no signs of copper in any form or variety. The substances pointed out by the guides as traces of ore were thin films of an impure sulphate of alumina, of a pale yellowish to pale dirty green colour, a recent product of decomposition due to infiltration, such as is often seen in damp excavations in similar rocks elsewhere, *e.g.*, in one of the two small caves nearer the summit of the mountain. Had the rocks ever contained copper ore, it is hardly possible that stains of typical character would not have remained. That Newbold had really found indications of copper ore cannot be doubted, so the only safe inference is, that the locality where the old mine was opened has been forgotten, which proves that it can never have been anything more than a mere trial sinking.

Copper at Harappanahalli.

Of the unquestioned finds of copper ore, the first and only one of any importance is close to Harappanahalli, in the more northerly of the great brecciated quartz-runs lying northward of the town (see page 172). The run, which is a large one, which rises at intervals into hilly ridges of some height, is crossed by the high road leading from Harappanahalli to Nandi Bevur (on the eastern side of the Mallapanbetta hill range). The road crosses a saddle in the ridge, and on the eastern side of this saddle, a few feet up the slope, some blocks of the quartz are seen to be coloured characteristically green by films of carbonate of copper in small patches. About half a mile further east-south-east, on the southern slope of the ridge, the quartz is for a distance of some score yards greatly copper-stained—the films of the bright green carbonate permeating the mass in many directions along innumerable small planes of fracture. They are very rarely as much as a line in thickness, and the aggregate quantity of the ore really very small, and not sufficient evidently to make mining remunerative, for it was abandoned after a couple of small terraces had been excavated into the side of the slope from which only a few tons of stuff could have been raised.

The old mine.

The age of this old copper mine was not ascertainable from the local officials, nor from any of the resident natives of whom I made enquiry. It appeared to have been completely forgotten. A good piece of the ore, richer a good deal than the average stuff, is among the specimens I deposited at the Survey Office.

Copper in the Siddapan Konda run.

The second locality showing traces and mere traces of copper in the form of a few green carbonate stains in the quartz occurs in the great brecciated quartz-run, extending eastward from the high quartz-crested Siddapan Konda ridge. The exact spot is on the highest point (locally) of the ridge, 2½ miles east by north of Hallalgundi.

Traces of other metals, such as antimony and lead, were met with by Newbold in the Sandur State, but he does not give their localities, and I could not trace them, and came across no indications of them myself.

e. Building and ornamental stones.

A considerable variety of building stones are raised in Bellary district, and the great majority of them may be set down as granites of different kinds, varying in colour and texture, and the ease with which they can be quarried and dressed. The number of quarries is great, but none are of very large size, and there is room for hundreds more if any demand for the stone were to spring up. Many very handsome varieties occurring in outlying places seem to be quite unknown, and attention will be drawn to them.

Varieties of granite.

The granites may be classed in two principal groups—(*a*) close grained granites, and (*b*) porphyritic granites. The former are much more extensively quarried than the latter, probably because more easily worked and more frequently found in sound condition, weather action having in most cases penetrated them to much less depths than it has done the coarsely crystalline porphyritic varieties. The latter, however, when cut from freshly exposed non-weathered masses and well polished, are of very

great durability, as may be seen in various very ancient buildings.

Granite-yielding localities and quarries.

A list of the principal localities where granites of different kinds have been raised, or where they occur awaiting trial, is given in Appendix A. The supply of first class rock of this kind is, if the district be considered as a whole, absolutely inexhaustible.

Dammur red granite.

Of the granites that have not attracted notice as yet and do not appear to have been at all quarried, one of the most striking is the red granite (syenite) occurring between Dammur and Bailur (Byloor), 11 miles due north of Bellary along the high road to Sirguppa. This rock, which is of medium to rather coarse grain, is of a rich deep red colour, and would make a superb decorative stone if well polished. It forms a small hill about halfway between the two villages just named, and is procurable in large quantity.

Toranagal porphyry.

Another very handsome stone is the dark porphyry which occurs on the north side of Toranagal hill in Hospet taluq, 18 miles west of Bellary. The dark blackish-grey base is full of bright flesh-colored felspar crystals of large size. The porphyry is apparently a vein intrusive in ordinary grey granite. The quantity of it does not appear to be large, but a very similar, if not identical, rock occurs in the Kurikuppa hill not quite 3 miles to the north-west.

Examples of worked granite at Vijayanagar.

Some of the most remarkable specimens of worked granite in the district are to be seen among the ruins of the old Hindu capital at Vijayanagar. As, for example, the composite pillars in front of the great Vithalaswami's temple, and in the better preserved Kalyana Mantapa in the precincts of the same temple. Among the monoliths, remarkable for their size, are a great figure of Narasimha in a small enclosure west of the road south of the Hampi rise, and the great stone trough among the ruins south of the palace. The trough measures no less than 41′ 3″ by 3′ by 2′.

Another remarkable specimen of carved granite is a very large and handsome stambha or lamp post, of grey colour, to be seen at Korlagundi, a village 10 miles north-north-east of Bellary. This was said to have been quarried at the Kapgal hill, 7 miles to the south.

Great stambha at Korlagundi.

Of the non-granitic rocks suitable for building stones, the trappean rocks are the most largely represented in nature, but none of them, so far as my observation went, have been used in that way, though many of the lighter greenish diorites are stones of great beauty. Where prophyritic in structure, as they occasionally are, they are yet more strikingly beautiful.

Trap porphyries.

A lovely example of such a trap porphyry occurs at Hurlihal (Hoorlyhall) in the south-east corner of Kudligi taluq: rich green crystals of felspar show out of a blackish green matrix in large numbers. The dyke cuts the famine road (which runs from Hurlihal eastward to join the Bangalore-Bellary high road), about half a mile east of the village, and here several large blocks of the trap had been recently blasted and showed the extreme beauty of the rock to perfection. The dyke is over two miles long and of good size, so the quantity of stone it could furnish is very large. I commend this beautiful green porphyry and the red granite of Dammur and Bailur hill to the earnest attention of the Madras School of Arts.

At Hurlihal.

Another very lovely trap porphyry of somewhat similar character occurs at Kallakurti (Cullacoortee) in a small dyke close to the right bank of the Haggari river about 1½ mile south-south-west of Malyam (Maulyan) in Raidrug taluq. The loose blocks forming the surface of the dyke have been carted away by the villagers, but the dyke itself remains, though much obscured by cotton soil.

At Kallakurti.

A few handsome pillars of polished porphyritic diorite are to be seen in one or two of the old ruined temples at Vijayanagar.

The very numerous and often large dioritic dykes, so characteristic of the granitic regions of all parts of the Ceded Districts, Bellary district included, which can be made to yield road-metal of the very finest

Trap rocks as material for road-metal.

type, are now-a-days systematically neglected by the road authorities, who elect to use white quartz, because more easily collected in fragments and more easily broken, though it is the very worst material they could possibly choose.

Jasper rocks.

No use is or has ever been made as far as I can gather of the vast quantity of splendid riband Jasper rock occurring in the Sandur hills, especially in its eastern sections. This splendid stone certainly deserves the attention of the Madras School of Arts. The variety of tints it occurs in from bright scarlet red to the most delicate pinkish white on one side to deep red and purple to grey on the other, recommend it as a lovely material for inlaid work, such as the Agra work and mosaic, as well as for tablets and slabs and pedestals of all sizes.

The best places for collecting fine specimens of this jasper rock are: "*a*" The corner in the hills at foot of the Timappaghar (Timanghur of sheet 58), a small ruined hill fort perched on the top of the western side of the range, 3 miles north of Sandur town.

"*b*." On the top of the ridge, north of the little fort here, the beds have been much contorted, and the rock often shows beautiful and complicated "vandyked" patterns of the lamination, both on a large and a small scale.

"*c*." About two miles to the north-west by north of Timappaghar on the northern side of the range, and just within the boundary of Sandur State, rise some noble cliffs from 300 to 400 feet in height forming one side of a very lovely and thickly-wooded ravine known locally as the Ramgol. The great cliffs are formed of banded jasper-hæmatite of vivid red and purplish grey, or greyish brown in stripes and often exquisitely vandyked. This riband jasper is one of the most richly coloured rocks I have ever seen, and is even in the rough a material of great beauty. In the great fallen and broken blocks at the bottom of the ravine it is seen to much greater advantage than in the weather-beaten faces of the great cliffs. The jointing is most rectangular and very kindly and well shaped blocks of sizes, varying from a foot cube to several cubic yards in bulk, could easily be quarried.

"*d*." Similar rocks of almost equal beauty are to be met with in the beautiful cliffs of Ubbalagandi[1], a little village lying 7 miles east-south-east of Sandur, and just outside the state boundary.

"*e*." On the little ghat path leading from the Ettinahalli bungalow to the Forest Officer's bungalow on the top of the Donimali, the plateau lying south of the Bhimagandi pass is another show of beautiful jaspery rock, and both here and at Ubbalagandi is a more highly siliceous variety of it in which the lamination is much less distinct, and the red colour distributed in spots and clouds through a whitish or more rarely bluish-grey mass. This too would lend itself admirably to inlaid work.

The green quartz found in the shingle scattered over the country and Nemkal (Naimcul) south of the Nimcheri hills, and the green quartzite occurring in the Dharwar bed close to Metra on the road from Daroji to Kampli, are both susceptible of being utilized as very pretty ornamental stones.

Potstone.

Another valuable and important stone, as a building stone, is potstone or steatite which occurs in considerable quantities in several parts of the district, and which has been used with excellent effect in the construction of several temples in the extreme western taluqs. Notably in the temples at Hira Kuravati and Nilgunda in Harappanahalli taluq and at Hira Haddagalli in Huvina Haddagalli taluq.

In all three cases the temples are largely and very beautifully carved, and the carvings have generally resisted weather action extremely well.

Localities for potstone.

The most important source of the potstone is the Nilgunda hill and the band of similar rock which stretches away three miles or more to the south-south-east.

An old disused quarry of good grey potstone occurs a mile south of Angur (Ungoor) on the Tungabhadra, 4 miles to the west-north-

[1] These Ubbalagandi cliffs must not be confounded with those of the western Ubbalagandi gorge by which the Nari Nalla enters the Sandur valley.

west of Hira Haddagalli, and was the probable source which supplied the material for the temple there just referred to.

Domestic utensils of potstone.

The bands of potstone occurring a mile or so west of Harappanahalli town seem to be unworked, and so also the rather coarse mass of the stone forming the Arsapur hill, 9½ miles south-south-east of Harappanahalli, but on the low rise north of the hill are a number of pits from which a quantity of greenish-grey steatite of good quality is raised for conversion into bowls and platters of divers sizes and shapes for various culinary and other domestic purposes. The industry was only a small one at the time of my visit, and the workmen handicapped themselves by using very clumsy flat chisels instead of gouges for excavating the vessels manufactured. A very large number of the failures were clearly attributable to the clumsy shape of the chisels used.

Nobody was at work when I examined the pits, but at Somalapur, 4 miles south-west of Sandur, where a similar stone was worked, the operator admitted the great superiority of a gouge of English make, but said he could not procure one, and that the native smiths could not make him one. The external shaping of the vessels was done very neatly with a miniature adze.

The potstone band east of Uchingi Drug was unworked as far as my enquiries went.

Crystalline limestones.

Of true crystalline or compact limestones, as already observed, very few examples were met with in Bellary district, and of those noticed none had been worked, though in each case a small quantity of nice-looking useful marble could be produced.

The cases referred to all occur in the Dharwar series.

Localities where found.

The limestone to the south of Birrabi hill (see p. 80) in Haddagalli taluq like that 6 miles west by south of Huvina Haddagalli (p. 86), and like the outcrop at the base of the Dharwar series 3 miles E. 5° N. of Harappanahalli (p. 86) is grey to greenish-grey in colour.

The small beds of grey or creamy white crystalline limestone near Tallur (p. 127) were insufficiently exposed to judge of their real value. It might be worth somebody's while to remove the surrounding soil sufficiently to ascertain their true size and possible worth, for they are only about 3½ miles south-west of Toranagal station on the Bellary-Gadag branch of the South Mahratta Railway. The small bed of highly crystalline limestone exposed between two trap flows near the ruined village of Hattigenhalli, about 2½ miles south-south-west of Toranagal, would appear too small in extent to be worth looking after.

Lime-burning.

Lime for building purposes is procured in very many places from sub-ærial or alluvial formations of kankar or nodular limestone which are very commonly met with near to or on the surface of the hornblendic and other basic rocks occurring so largely in the Dharwar system as flows and dykes.

Slates.

No true slates useable for roofing or flagging purposes were met with anywhere in the Bellary district.

Mineral pigments.

Some of the paler argillite schists and clayey traps weather on a large scale into soft semi-ochreous masses which are very suitable for pigments, and are used to some extent in the districts as colour-washes for house painting; these are derived from the Dharwar series. The commoner colours are dull orange and drab, but purplish grey and lilac are met with, and red tints ranging from pale pinkish to deep red in the softer hæmatitic beds are met with. The most of these were seen on the flanks of the western or Ramandrug section of the Sandur hills (see page 193). A great show of rich red ochre occurs on a low hill west of Chiggateru in Harappanahalli taluq.

Clays for common pottery and brick-making are found abundantly in the river alluvia, but no high-class clays, much less pure kaolin, were found in the older rocks in workable quantity.

The mottled white and red argillite occurring close to the well known temple of Kumaraswami, south of Sandur, has been referred to by Captain Newbold as a kaolin available for high class pottery.

This is a great misapprehension, the material is far too extensively stained, and would require crushing and hand-picking to an extent that would render it far too expensive a material for practical purposes (see page 120).

CHAPTER XI.

PREHISTORIC ECONOMIC GEOLOGY.

It may not be uninteresting to say a few words about the evidences met with of the use of many kinds of stone by the earliest inhabitants of this part of the world.

There is plentiful evidence that this part of India was occupied by a succession of peoples who had attained to very different grades of civilization, each succession showing a great advance on its predecessors, but there is not sufficient evidence at present to determine the racial affinities of these several peoples with any precision, and to prove, or disprove, whether there was any descent among them.

Three stages of civilization traceable.

Palæolithic stage

The existence of three principal stages of civilization may however be considered as distinctly established for the prehistoric times of the Bellary country; these were the following: 1. A palæolithic stage, when the only implements made (as far as is known) consisted of hard stone chipped roughly into shapes useful for cutting and thrusting, and possibly for hammering, the favourite shapes being ovals of various proportions, varying from almost true circles to very elongate lanceolate forms that might be termed spear heads. A much rarer type is oval at one end and has a broad axe-like edge at the other end. Such implements are at present the only known traces of this ancient people.

Neolithic stage.

2. A neolithic stage, when the implements were in the first stage chipped, but more carefully, into the required shapes, then picked and ground to sharp edges or all over, as the case might be, and finally polished to a high degree. They differed in type as a rule from the palæolithic implements, the great majority having the cutting edge at their broad end,

while the Palæolithic implements all (the rare axe type excepted) have their cutting edge at the narrow end.

Early iron stage.

3. The early iron stage, when the axes made of iron, were in shape imitations more or less close of the best polished stone implements. There is much evidence pointing to the fact that these two stages met and overlapped each other, and that for a time the two implement-making industries were carried on simultaneously. Eventually, of course, the great superiority of the iron implements led to the cessation of the stone chipping and polishing industry which must have been immensely more laborious and time consuming.

No copper or bronze stage.

Of a copper or bronze stage no traces have come to my knowledge. For particulars of the finds of settlements of the neolithic and early iron people, I would refer the reader to a paper I read before the Bengal Asiatic Society in 1887,[1] but I have since then collected a very large body of further evidence, which I hope to publish before very long.

Break in time between the palæolithic and neolithic stages.

On the connection between the palæolithic people and the neolithic people by descent, the new evidence obtained in Bellary is purely negative, but I have since obtained other proofs in the valley of the Sabarmati river in Northern Gujarat, which appear to me to confirm very strongly the assumption put forward in the paper just referred to, and previously,[2] that a very great break in time lies between the palæolithic and neolithic periods.

Evidence in favour from the alluvium of the Sabarmati river.

The evidence now obtained is briefly this: That since the entombment in a certain gravel deposit, forming part of the old alluvium of the Sabarmati river of quartzite implements of the South Indian or Madras type, there elapsed a sufficient time for the accumulation

[1] Notes on some recent Neolithic and Palæolithico finds in South India. Journal, Asiatic Society, Bengal, and a letter to the Secretary, Natural History Section, Vol. LVI, Pt. II, No. 3, 1887, dated 26th November 1888, published the same year.

[2] See Madras Journal of Literature and Science, Vol. XV, for 1866, for an account of the discovery of quartzite palæolithic implements in the coast laterite.

above that particular gravel, of a thickness of full 60 feet of other gravels and loam beds, and of a deposit of from 80 to 150 feet thick of loess. On the surface of this loess, and to a depth of 2 or 3 feet below it occur numerous traces of the existence of a neolithic people. No traces of the neolithic stage were found at greater depths, though many hundreds of sections were examined, but the traces on and near the surface of the loess are distributed far and wide over the country.

This evidence of a great break in time between the palæolithic and neolithic peoples is an almost conclusive argument against there being any connection by descent between them.

Palæolithic implements in a talus-fan.

The very earliest traces of man's existence in the Bellary district as yet met with are the rude chipped implements above referred to, of which I made the first find on the surface of one of the great shingle talus-fans lying round the north-eastern end of the Copper Mountain. I got in all about 30, of whose genuinely human origin there could be no doubt, and all were made of hæmatite-jasper, and all of shapes commonly found among the lateritic gravels of the Madras Coast, such as ovals and pointed ovals, and much more rarely of the hatchet shape, but all found here were of rather smaller size than the average coast laterite specimens. They had been ploughed up out of the surface of the fan. I searched many stream sections through the fans there and further west, but nowhere succeeded in finding implements exposed in them, but I got two excellent specimens on the surface of a similar talus-fan at Joga, 22 miles to the west-north-west. Both of these are of hæmatite-jasper.

In the Joga talus-fan.

Another very typical implement of hæmatite-jasper was found by me on a ledge of rock on the side of the bold granite hill which rises out of the flat at the upper end of the Great Daroji tank, north of Kurikuppa.

North of Kurikuppa.

Quartzite implements of palæolithic type were very rare; the only one I succeeded in finding, despite much hunting of the old alluvial shingle beds of the Tungabhadra and the other rivers, was an oval

Quartzite implement in the old alluvium of the Tungabhadra.

specimen of the ordinary coast laterite type. It had been washed out of the high-level shingle bed west of Nittur on the north bank of the east to west reach of the Tungabhadra, 15 miles west-south-west of Harappanahalli.

Absence of palæolithic implements from prehistoric hill sites near Bellary.

I did not myself come across genuine palæolithic implements of any kind or material within the limits of any of the many neolithic sites on the hills around Bellary, though I searched for them strenuously (except in the case of the solitary hæmatite-jasper implement just referred to, lying loose on the bare surface of a rock on the hill north of Kurikuppa).

I saw no palæolithic implements of any sort whatever in the collections from the environs of Bellary and the Kapgal (Peacock hill) made severally by my friends Mr. Robert Sewell, the Collector of the district, and Mr. Henry Gompertz, Deputy Superintendent, Survey of Madras, but I obtained a very doubtful specimen of the small pointed type through the kindness of Mr. Hubert T. Knox, some time Judge of Bellary, who, when he retired from India, very generously sent me a good number of specimens, mostly very choice ones of neolithic age, to add to my collection. The specimen is an interesting but very doubtful one, and I cannot make up my mind about its true age, but am most inclined to regard it as an ill-shapen neolithic implement in the first stage of manufacture, and extremely weathered. That the palæolithic people whose implements were found in some number in the talus-fans of the Copper Mountain and on the north-east section of the Sandur hill group, ranged over the hills on which the neolithic stone-chippers long subsequently established important settlements and, as at Kapgul, a celt-making industry on a rather large scale, cannot be doubted; but that they had a regular settlement there, as asserted in several letters to the *Madras Mail* in 1891 by Surgeon-Captain Fox, A. M. D., I most positively doubt, for I met with no traces of them when I examined Kapgul hill most carefully on several

Alleged palæolithic settlement on Kapgal.

occasions, years prior to Dr. Fox's visit there, and made large and valuable collections of neolithic implements, pottery, and ornaments of many kinds. That I should, with my long and great experience in palæolithic archæology in South India, dating from 1863 (when I discovered the first palæolithic remains in South India), have overlooked important and extensive evidence of a palæolithic colony at that place, is utterly improbable. Had such evidence really existed, I must have seen it, and should have been delighted with the find which would have been unique, and to me of most special interest. When Dr. Fox's letters appeared in the *Madras Mail* I wrote to that paper, to call upon him to produce evidence in support of his claim by describing the character, shape, and material of the implements he had found, but these questions he never answered, and merely reiterated his assertion as to their being palæolithic, and resented in rather unmeasured terms my having questioned the palæolithic age of his finds, so I can only believe that he mistook unfinished neolithic implements for palæolithic ones, because they were in a merely chipped condition, the first stage of manufacture they all passed through. He further claimed to have found palæolithic pottery with the rude stone implements, but this discovery I must also reject. Of the hundreds of fragments of old pottery I handled on the top of Kapgal, the site of his palæolithic colony, not a single one was hand-made; all were wheel-made and kiln-baked! Had I found hand-made and sun-dried vessels, I should at once have decided that I had hit upon some thing much older than an ordinary neolithic settlement. In this case too Dr. Fox failed to adduce any real evidence in support of his alleged find. He alleges that he found sun-dried hand-made pottery, but in this assertion nobody supported him; certainly not my friend Mr. Hubert Knox, then Judge of Bellary, to whom he presented his finds. Mr. Knox's opinion in the matter I would have accepted at once.

Reasons for doubting it.

The controversy I had with Dr. Fox extended to another

question, namely, the probable glacial origin of the present topography of the environs of Bellary, a view he advanced very strongly, but which I can only regard as utterly without foundation. His hypothesis on this matter will be found quoted in Appendix B.

Tabular list of varieties of stone used by the prehistoric people.

The varieties of stone that had been used by the prehistoric inhabitants of Bellary district are enumerated in the following table, which I quote with a little modification and addition from my paper published in the Journal of the Asiatic Society of Bengal (Vol. LVI, Part II, No. 3, 1887).

Varieties of stone selected for use.

Granite	For mealing stones, corn-crushers, mealing-troughs, polishing and edging places for celt-making on the rock terraces, deep troughs on big blocks for holding water.—A single celt.
Epidote-granite	Corn-crushers } These were evidently very favorite stones and often fetched from long distances.
Green gneiss	Mealing-stones. }
Greenstone of several varieties	Celts, hammers, chisels, ringstones, pestles, mealing stones, corn-crushers, strikers, scrapers, flaking-tools, flakes.
Quartz (very rarely used)	Corn-crushers and scraper. Strike-a-lights?
Siliceous breccia of Dharwar age (very rarely used).	Mealing-stones.
Hornblende schist (a very silky variety).	Celts of a flat type, found numerously at Gadiganur, but very rare elsewhere. Pestles.
Chlorite schist	Small ringstones, beads.
Steatite	Do. do. do.
Slate, purple	A human figure in long garments; head wanting.
Quartzite	Mealing stones; hones; beads (very rare.)
Hæmatite-jasper	Mealing-stones; corn-crushers.
Jasper, red	Beads (rare).
Hæmatite-schist	A small figure of a bull crouching, with three holes drilled through the base. A talisman?
Hæmatite, red, earthy	As pigment (rouge), as an ore for iron in post-neolithic sites.
Agate	Cores, flakes, and beads.
Carnelian	Beads, cores, and flakes.
Chert	Cores, flakes, flake-knives, scrapers, strikers, slingstones, strike-a-lights.
Clays	For pottery.

Prehistoric pottery, its characters.

The prehistoric pottery, whether neolithic or of the early iron age, is mostly of high class for Indian pottery, much of it far superior to what is now made in those parts. It will not of course compare with Etruscan or Greek or Egyptian pottery, but many specimens were met with showing great elegance of form with superior quality of the clay worked into them.

The best and most typical pottery is red and black, rarely brown or creamy in colour, and is covered with a shiny but non-fused glaze. This glazed pottery is not made in the district as far as I know at the present day. The discovery of fragments of such pottery is often an indication of the existence of a prehistoric site, and has often led me to search for and find such sites.

Among foreign stones imported by the old people were garnets and lapis-lazuli which were used for beads ; the former being cut *en cabochon*, and both fairly well polished.

A few beads of white coral were also met with.

APPENDIX A.

List of quarries and localities in Bellary District where granite of good quality can be raised.

I.—In Bellary Taluq.

1. The Fort hill . . .	Rock grey, moderate grain, west side of hill quite scaled by continued quarrying.
2. West of the Jail . .	Quarry, rock grey, moderate grain.
3. West of the Civil Dispensary.	Quarry, rock grey, moderate grain.
4. Mainwaring's tank . .	Excavated, rock purplish-grey; moderate grain.
5. North hill, Bellary . .	Grey, pinkish, pale purplish, porphyritic.
6. Kollagal and intermediate hills.	An extension of the north hill band of rock.
7. The Kurgod hills, 14 to 16 miles north-west by west of Bellary.	Rock silvery-grey, moderate grain, very durable and handsome. Quarries at Waddahatti and Baddanhatti.
8. Dammur, and Bailur hill, 12 miles north of Bellary.	Deep red granite (syenite ?); a very handsome stone in large quantity.
9. Sirigiri hills, 20 miles north-north-west of Bellary.	Reddish granite.
10. Sangankal hills, 4 miles north-east of Bellary.	Pale grey, moderate grain, good.
11. Kapgal hills, 5 miles north-east by north of Bellary.	
12. Tekkalkota hills, south and west of, 30 to 32 miles north of Bellary.	Grey granite.
13. Hallakota band of hills, 33 to 35 miles north of Bellary.	Grey granite.
14. Virapur hill, 2 miles north-east of Virapur railway station, 15 miles east by north of Bellary.	Pale red and pink and black banded syenite. Very handsome.

II.—In Alur Taluq.

15. Chippagiri hill, 4 miles north-west by north of Guntakal Junction.	Grey. Has been largely quarried.
16. Ram Drug hills, 11 miles north-west of Guntakal Junction.	Grey. Very fine grained in the north-wes spur.

APPENDIX A—*continued.*

List of quarries and localities in Bellary District where granite of good quality can be raised—contd.

II.—In Alur Taluq—contd.

17. The Alur hill group, north-west of Alur.	A very large hill group with many handsome varieties in vast quantities.
18. The Hallalgundi hills, north-west of the Alur hills.	Grey granite gneiss.
19. New Guliem Hill, valley of the Haggari.	A handsome red syenite.

III.—In Adoni Taluq.

20. The Adoni fort hill and hills around it.	Has been largely quarried; many fine varieties.
21. The hills south-east of Adoni.	Banded grey granite-gneiss.
22. Kotakallu and hills to the north-west, 8 miles north-east by east of Adoni.	Banded grey granite-gneiss.
23. The Kaman Konda group, 12 miles north of Adoni.	Banded grey granite-gneiss.
24. The Kosgi hills, east and west of the railway, 16 miles north-north-west of Adoni.	Massive granitoid.
25. Havi hill, 20 miles north-west by north of Adoni.	Banded grey granite-gneiss.
26. Murvani and hills to the east of it.	Grey granite (? hornblendic).

IV.—In Hospet Taluq.

27. Toranagal hill, 18 miles west by north of Bellary.	A splendid large-grained porphyritic syenite.
28. Gadiganur hills, 6 miles west by north of Toranagal.	Flaggy grey micaceous granite-gneiss.
29. Daroji hills, east side of, 18 miles north-west by west of Bellary.	Silvery grey rock of moderate grain; a handsome stone largely quarried on eastern side of hill.
30. Waddarhalli hills, 8 to 10 miles east by south of Hospet.	Banded, shades of grey, moderate grain. Handsome stone.
31. Vijayanagar and Hampi hills.	Chiefly grey of moderate grain, some pinkish. Handsome stone.
32. Naganhalli hills north of Hospet.	Grey, of moderate grain; good stone.
33. Bookasagra hills, east of Vijayanagar.	Massive granitoid.

APPENDIX A—*continued.*

List of quarries and localities in Bellary District where granite of good quality can be raised—concld.

V.—In Raidrug Taluq.

34. Raidrug hills and fort .	Grey rock, moderate grain; has been largely quarried.
35. Kailasa hills.	Massive granitoid.
36. Valley of the Pennér.	Hornblendic granite.

VI.—In Kudligi Taluq.

37. Kudligi, hills north and north-east of.	
38. Jaramalla hills, 11 miles south-east of Kudligi.	Grey granite. Has been largely quarried.
39. Chornur, hills north-north-west of.	Grey and black banded granite gneiss.
40. Gudikota.	Bluish-grey banded granite-gneiss in immense blocks.

VII.—In Haddagalli Taluq.

41. Tambrahalli, hills north of.	Handsome banded granite-gneiss.
42. Hollagundi hill.	Hornblendic granite-gneiss.
43. Utingi hill.	Massive granitoid.
44. Timappan Gudda.	Much quarried.

VIII.—In Harappanahalli Taluq.

45. Bandé (Bunday) hill, 5 miles north-north-west of Harappanahalli.	A small-grained "Augen-gneiss." A good stone.
46. Harappanahalli hill, 2 miles south-west by west.	A handsome grey rock, largely quarried at one time.
47. Harappanahalli, hills south-east of.	Massive granitoid.
48. Sassevihalli, 10 miles south-east by east of Harappanahalli.	Grey rock, gives splendid flagstones of large size.
49. Narasimhdever Konda, 2 miles west of Arsakerra.	Handsome grey rock, largely quarried.
50. Uchingidrug hill . .	A handsome grey rock. Largely quarried to build the old drug and of late years for the South Mahratta Railway.
51. Kanchkerra hill . .	Good banded grey rock on hill south of village.
52. Sattur hills, west of Uchingidrug.	Grey granite-gneiss.

Appendix B.

Glaciers near Bellary.

A most wildly far-fetched but very amusing hypothesis, explanatory of the physical features of the environs of Bellary having been shaped by glacial action, was put forward a few years ago in a letter to the *Madras Mail* by Surgeon-Captain Fox, A. M. D., in connection with a controversy between us about his alleged discovery of a palæolithic settlement on the top of Kapgal (the Peacock hills, north-east of Bellary).

It had better be given in his own words to obviate any possibility of misconstruing his meaning:—

"I have also said that the rocks and boulders about Bellary bear unmistakeable evidence of the action of ice. My reasons for the statements are as follows:—In every new country you find lakes. None occur in this neighhourhood. They have been silted up ages ago. Volcanic action is always active in the vicinity of fresh upheavals of the earth, and, although earthquakes are said to have occurred in this district, there is no evidence of recent volcanic phenomenon (*sic*). In all countries that have been raised by the subsidence of water you will find the aqueous foundations of the rock abundant. In this district granite alone exists. It is an igneous formation and the oldest type of rock known. Therefore it must be of an enormous age. An almost continuous sheet of granite extends from the base of the Copper Mountains for 5 miles to the east of Bellary. This is covered for the most part by earth, detritus, drift gravel and sand which have been carried down from the Copper Mountain by ice, rain, and running water. At certain points however the granite rises boldly out of the sandy plain. Wherever this occurs the granite is split and cracked into huge boulders by the action of ice; and these boulders are rounded and polished, and scattered here and there by the propelling action of a pre-existing glacier. Many of these huge boulders, some as large as a house, have been carried away from the parent rock. These are known to glacialists as erratics. "Mercy's Umbrella," a boulder well-known in Bellary, is an erratic of this kind. Moreover, on the slopes of every granite hill immense mounds of round boulders exist, which have been broken off the parent rock by ice. The famous rock of Bellary is one enormous mass of solid granite which rises out of the plain 300 or 400 feet. To give an idea of its size I may say it takes one half an hour to climb to its top, and about one hour to walk round its base. The side facing the Copper Mountains, the "Stoss-seite" of the Swiss, is perfectly bald and free from boulders. The opposite side, however, the Swiss "lu-seite" is covered with thousands of large round boulders which have been pushed round to the lee side by glacial action and there deposited. Now, if you look at these rounded boulders from a distance of half a mile or so, they have an appearance as if a flock of brown sheep lay on the side of the rock. This peculiar appearance the Swiss glacialists call "*roches montonnés*" (*sic*) or sheep-backs. In like manner if we mount the upper fort and look from one of the bastions down the east side of the rock we will observe that the boulders present a smooth and undulating surface—an appearance which altogether vanishes if we stand at the

club and look upwards. This phenomenon, says Professor Geikie in "Prehistoric Europe," must be attributed to precisely the same cause as that which produced the *roches moutonnés*. And then as to perched blocks the place is full of them. One need not climb the rocks to see them, they are visible from the roof of the club. Some look like magnified eggs resting here and there on their ends; others seem like packs of wool or bales of cotton poised in such a manner that you could well imagine you could push them down. I have not seen any striæ, but there are plenty of ruts and parallel grooves visible.

"I think I have said sufficient to show that a glacier once descended from the Copper Mountains and passed over Bellary splitting, grinding, and pulverising all before it. Ice is the only force in nature known to me that could possibly have split and broken off the boulders and rolled them into the shape and position in which we find them. But there is yet another evidence which I will mention in proof that a very cold climate once prevailed in Bellary. Colonel Douglas Mac-Neile was sinking a well in his compound last year, and when he got down to the granite 40 feet below the surface, he found an arctic lichen embedded in the rock. The Colonel was kind enough to send it to me, and the fossil is now in my possession. Now we know that arctic moss does not grow on solid granite 40 feet beneath the surface, neither does that variety of moss grow above the surface in this present climate. *Ergo*, Bellary was once as cold as Greenland, and the rock which is now covered by 40 feet of gravel was once uncovered. In fact it is difficult for even human imagination to grasp the enormous age of Bellary and the extraordinary climatic changes which must have taken place. In conclusion, I would remark that Mr. Bruce Foote's heroic statement that he "never met the ghost of a trace of glacial action" is enough to take one's breath away. Such notions are evidently preconceived. They are very previous."

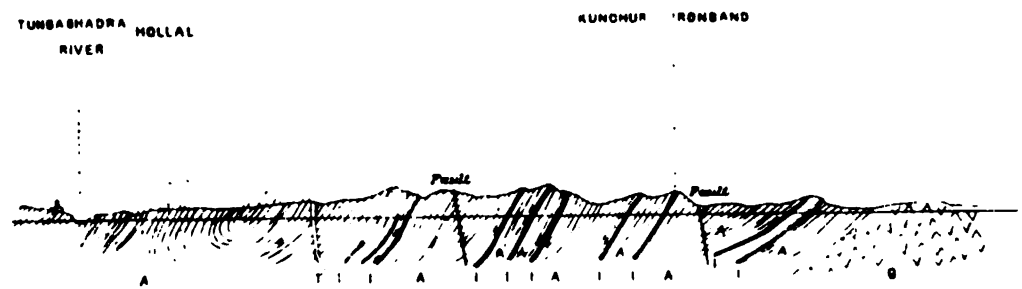
Dr. Fox assumes the existence of a glacial period at some time convenient to his hypothesis, but which is unknown to geologists. He postulates the existence of a huge glacier to produce the present appearance of the granite rocks in the neighbourhood. Not knowing the great tendency of granitic rocks to be cut up by great joint planes due to shrinkage on cooling, and their equally great tendency to weather concentrically along the faces of all the joint planes, he calls in a "deus ex machinâ" in the shape of ice, to cause the cracks and displace and round the blocks produced by the joint planes which he persists in calling boulders, *i.e.*, water rolled masses. For his glacier he has forgotten to provide a gathering ground of sufficient size and elevation—the Copper Mountain, even if a plateau, instead of a narrow ridge, could never have supplied such a vast ice-river as would have been required to convert the Bellary fort hill into a gigantic *roche moutonné*. To have got the vis-a-tergo to move such a gigantic glacier such a long distance a mountain many thousand feet higher than the Copper Mountain was required and this even if his glacial period be conceded to him. If it be denied him, he would, in the latitude of Bellary, have had to provide a mountain some 20,000 feet high to hold a sufficiently large snowfield to produce his big glacier and to supply the ice stream with the power to move some 7 miles out into the plain and attack a big hill some 450 feet high and convert it into a gigantic *roche moutonné!* He would also have had to arrange conditions to prevent his glacier from melting long before it got down to the level of the Bellary plain which

is only between 1,500 and 1,700 above sea-level. The fort hill itself would have been the *roche moutonné*, and not only the blocks that Dr. Fox manages to make the ice push round to the eastern side of the hill. Tors and blocks have remained where they were formed, because the east side of the hill has not been quarried! The doctor has to explain further what has since become of the great mountain? Furthermore, why was not the south-west side of the north hill glacially denuded as well as the fort hill? and why are all his "perched blocks" masses belonging to the hill on which they rest? instead of rocks foreign to the locality borne thither and left there by the ice, which is what glacialists understand by a "perched block." Lastly, he should have explained the process by which the "Arctic lichen" that was found by his friend (when sinking a well) growing on the surface of the granite had by the time it came into his possession become a "fossil embedded in the rock," a once molten rock formed millions of years anterior to his glacial period! His ideas on this matter seem to be not a little mixed!

R.B. Foote.

Memoirs. Vol: XXV. Pt 1.

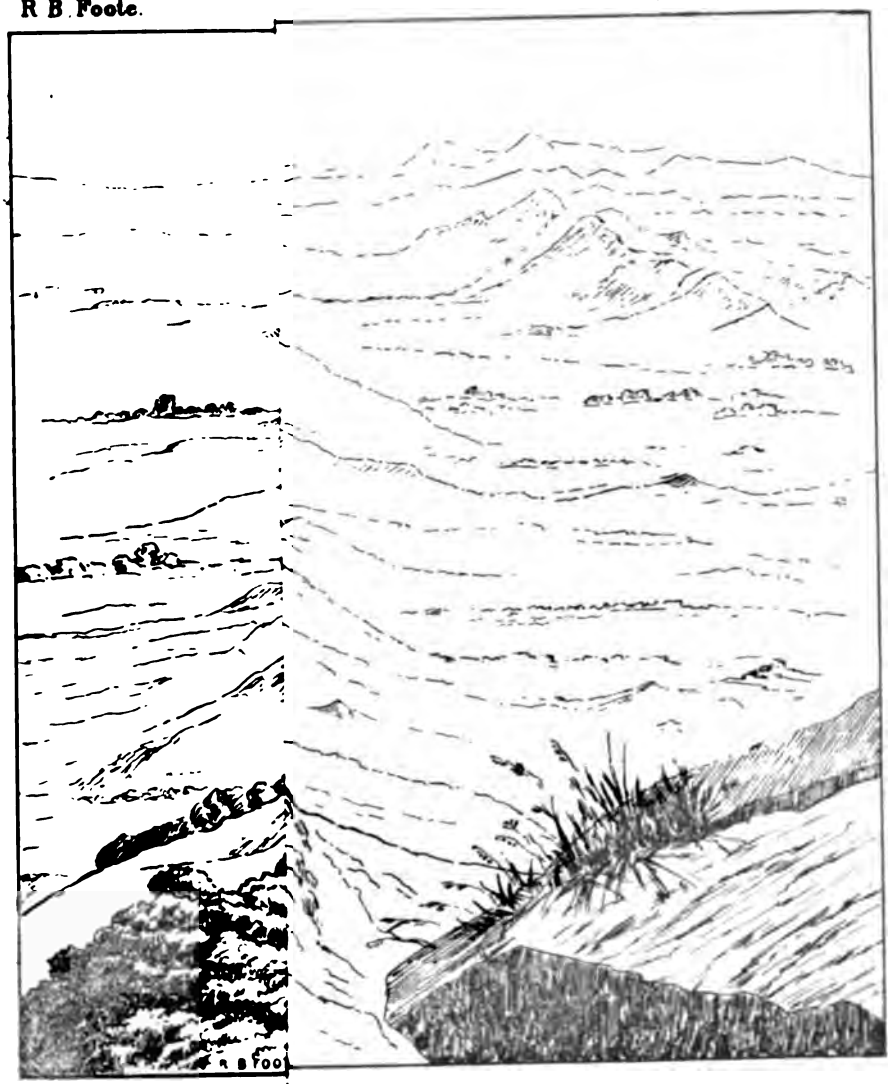
SECTION ACROSS THE KUNCHUR TRACT FROM THE TUNGABHADRA SOUTHEASTWARD THROUGH HOLLAL. 18 MILES.



REFERENCE

R B. Foote.

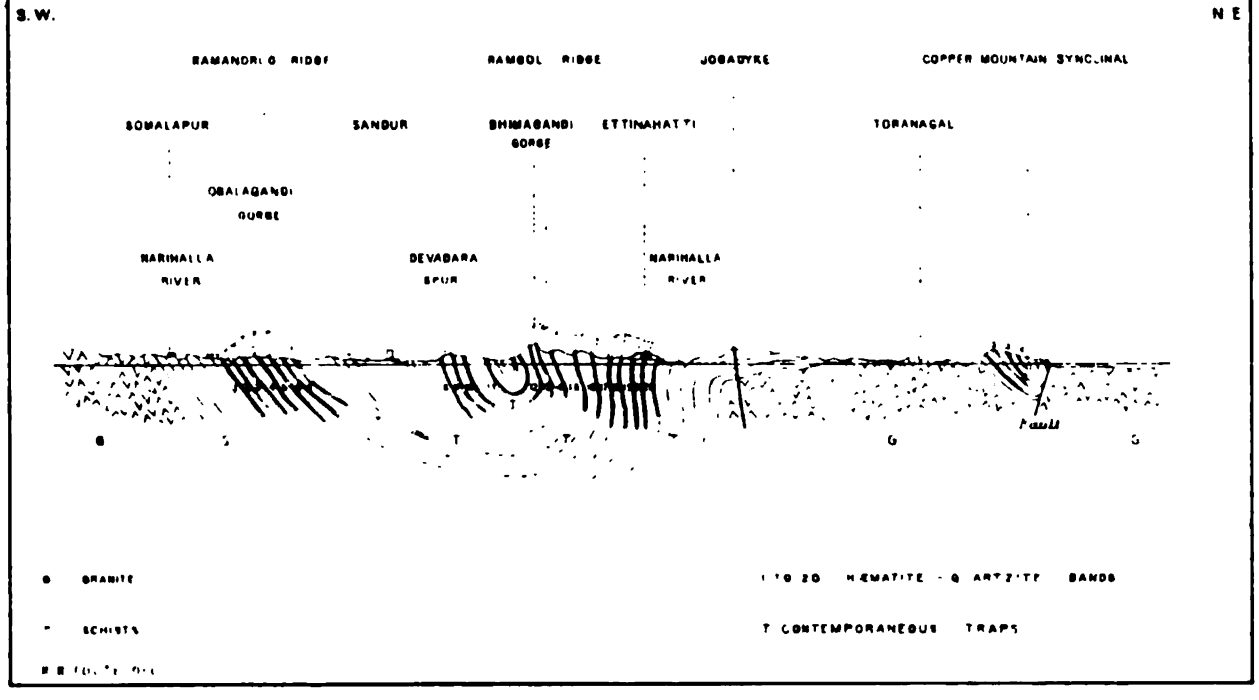
Mem. Vol. XXV. Pl 2.



R.B. Foote. Memoirs, Vol: XXV. Pl.III.

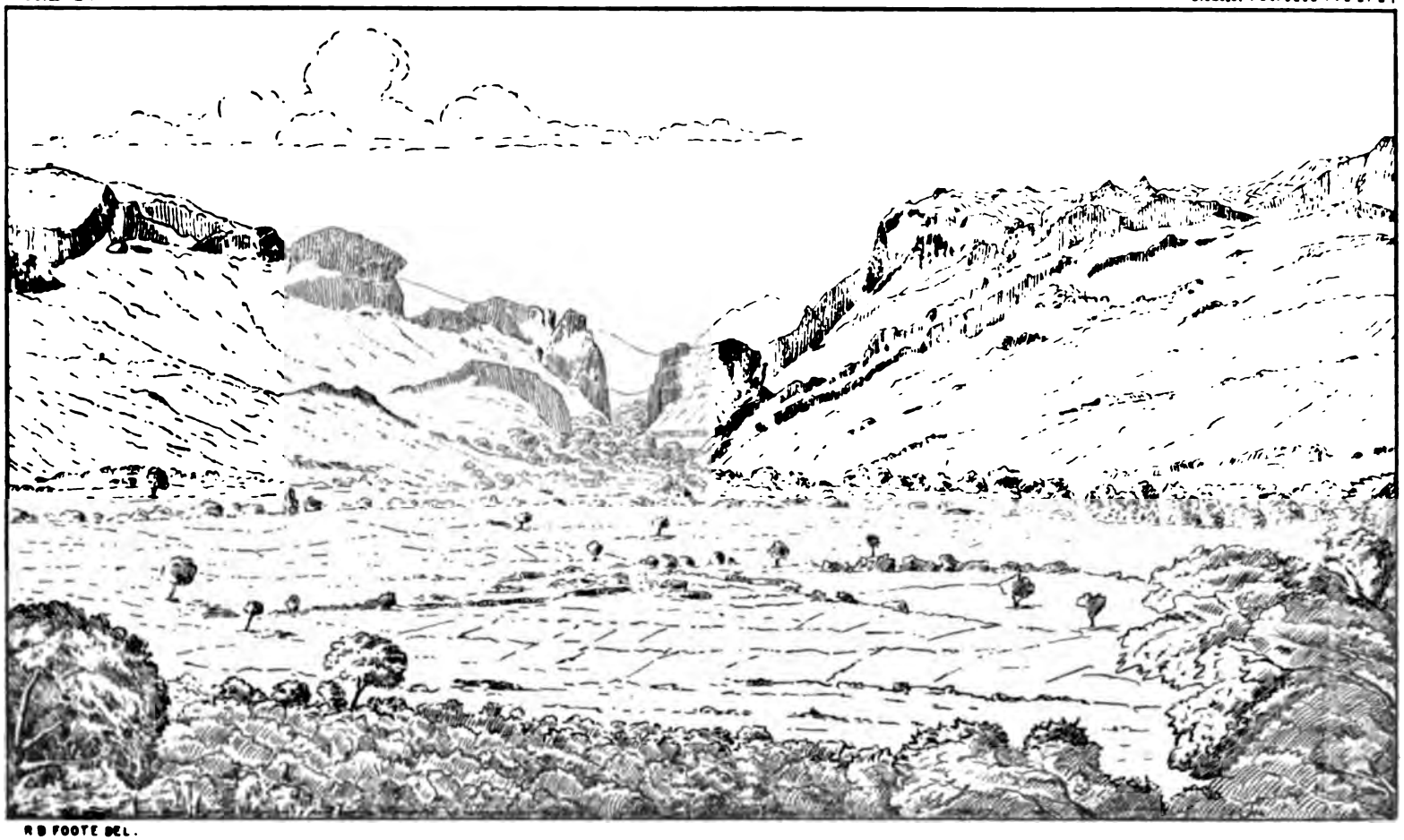
SECTION ACROSS THE SANDUR AND COPPER MOUNTAIN SYNCLINALS. 24 MILES.

(Diagrammatic)



R.B. Foote.

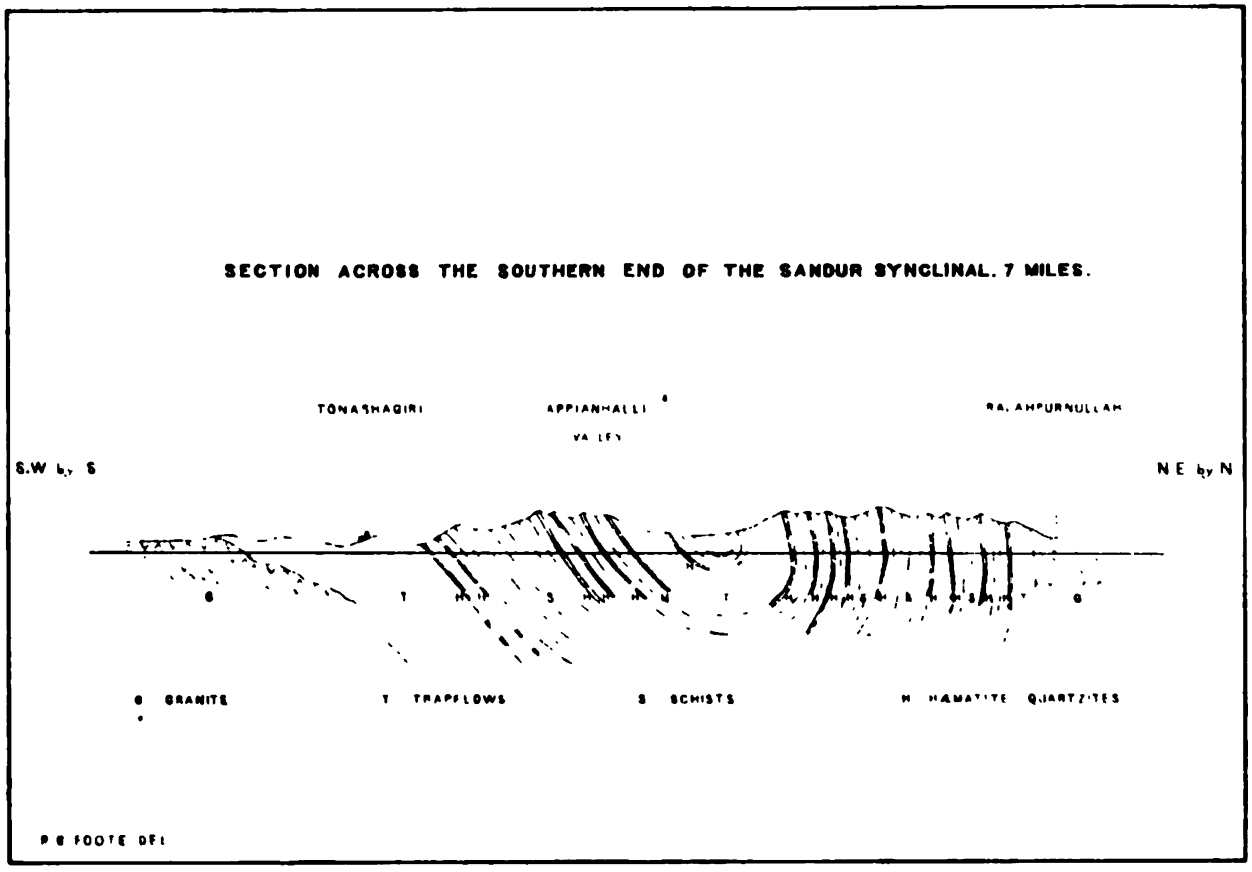
Mem. Vol. XXV. Pl. 4.



THE BHIMAGANDI GORGE SEEN FROM THE EAST.

R.B. Foote.

Memoirs, Vol: XXV. Pl. V



R.B.Foote Mem. Vol.XXV.Pl. 5, a

R B FOOTE DEL.

THE UBALAGANDI GORGE OF THE NARI HALLA.

R.B. Foote. Memoirs, Vol: XXV. Pl.VI.

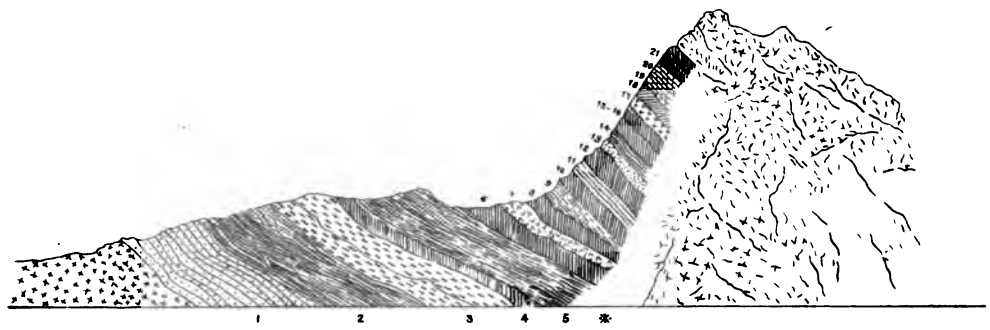


DIAGRAM OF SECTION OF NÉMKAL HILL. 1/2 MILE.

* *Abutment contact not seen, hidden by talus. For numbers see page. 144.*

R B. FOOTE DEL.

Part 3.—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus Sphenophyllum and other Equisetaceæ, with reference to the Indian form Trizygia Speciosa, Royle, (Sphenophyllum Trizygia, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

Part 4.—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgujah. On volcanic foci of eruption in the Konkan.

Part 2.—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

Part 3.—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

Part 4.—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The reh soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

Part 2.—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.

Part 3.—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, north-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.

Part 4.—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi *vid* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

VOL. XV, 1882.

Part 1.—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dibing river, Upper Assam, and on platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and results of the International Geological Congress of Bologna.

Part 2.—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himalaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.

Part 3.—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himalayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanoung division of the Henzada district.

Part 4.—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. On the genus Richthofenia, Kays (Anomia Lawrenciana, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.

Part 2.—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of Hippotherium antilopinum. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.

Part 3.—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of Mastodon angustidens in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

Part 4.—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himalayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himalayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

Vol. XVII, 1884.

Part 1.—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus Lyttonia, Waagen, in the Kuling series of Kashmir.

Part 2.—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Choi coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

Part 3.—On the microscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, South-west Khasia Hills. Additional notes on the Umaria coal-field.

Part 4.—On the geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and Phosphatic rocks at Musuri. Work at the Billa Surgam caves.

Vol. XVIII, 1885.

Part 1.—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field-notes.

Part 2.—A fossiliferous series in the Lower Himalaya, Garhwal. On the probable age of the Mandhali series in the Lower Himalaya. On a second species of Siwalik camel (Camelus Antiquus, nobis ex Fale. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

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